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Science Education

THE ADOLESCENT "INTERESTED IN SCIENCE"

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The adolescent interested in science is in some ways a person apart from other young people. His interest in science has produced new forms of activity, new ideas and new problems for him. Science education gives little consideration to these young people who envisage themselves the scientists of tomorrow. This is largely because the focus of secondary education is on the average student. When schools do attempt to consider these interested students the way is blocked by a basic lack of knowledge of them, their activities, ambitions and problems.

To determine the characteristics of adolescents interested in science and the implications of these for science education is the aim of this phase of a larger study of the science interests and activities of adolescents.[1] Adolescents interested in science were selected on the basis of voluntary participation in science activities; such activity being considered presumptive of interest. The American Institute of the City of New York, through its junior activity program, has brought one type of such voluntary activity to a focus. A Science Fair is held annually at which individuals may exhibit. Participation is voluntary. The study of individuals who participated in this activity gave a sampling of science-interested adolescents, as all secondary schools in the metropolitan area were represented and there were no limitations on sex or age (up to 18) or on types of exhibits shown.

The methods used in gathering data included:

1. An analysis of 1576 individual entry blanks to the Fair over a period of seven years.
2. An entry-by-entry analysis of the content of 506 exhibits at the Fair for two years.
3. Questionnaires filled out by 230 exhibitors at the Fair for two years.
4. Autobiographies written by 111 exhibitors at the Fair during one year.
5. Correspondence with selected exhibitors at the Fair one year later.

The findings from the analysis of the entry blanks and from the contents of the exhibits have been previously reported. However, four facts should be repeated as they are germain to this discussion. First, boys outnumbered girls 5 to 1 in Fair participation. This ratio represents a fairly accurate picture of sex differences in science interest and activity. Second, interest, as measured by voluntary activity, varies in the different fields or areas of science. "Biological" interests (mainly in animals, physiology and health) are the strongest. Third, the interests of boys and girls show definite differences. Fourth, science interests of adolescents are stable, but undergo gradual changes with a diminution of sex differences.

These four facts are important because other phases of this study[2] have shown that they hold true for unselected adolescents as well. In other words, in ratio of participation, differential preferences, sex differences and permanence of interest, adolescents interested in science do not differ conspicuously from those who are not. This and other data indicate that the adolescent who is interested in science must first be considered as an *adolescent* and secondly as a potential scientist. Before considering this implication, it is nec-

[1] Zim, Herbert S. *Science Interests and Activities of Adolescents.* Ethical Culture Schools, New York, 1940. p. 256.

[2] *Ibid.*, Chapters III–VIII.

essary to examine the findings of the research, particularly those based on the responses of the 230 Fair exhibitors who filled out questionnaires. The large percentage of replies is an indication of the interest of these young people in science, as no inducements were offered other than cooperation in a research project. It must be remembered that girls participated only slightly in the Fair and of the 230 exhibitors 191 were boys and only 39 were girls. While the data obtained from boys are fairly conclusive, that from the girls can only be suggestive because of their limited number.

The time spent in preparing the science exhibits, as reported by the 230 exhibitors, varied from less than ten hours to more than two hundred hours.[3] Thirteen per cent of the exhibitors took more than one hundred hours to prepare their exhibits. The average time was as follows:

Jr. High School		Sr. High School	
boys	63 hours	boys	70 hours
girls	40 hours	girls	63 hours

When the spare time of adolescents in high school is considered, the work on these exhibits represents a major undertaking, often spread over a period of several months.

The choice of exhibits at the Fair which exhibitors liked best revealed the following preferences:

EXHIBITS AT SCIENCE FAIR PREFERRED BY EXHIBITORS

	Biological	Physical	Miscellaneous	Total exhibitors
Grade 7–8–9				
boys	15	43	13	71
girls	4	1	4	9
Grade 10–11–12				
boys	13	39	13	65
girls	10	7	0	17

Boys on the junior high school level showed a strong preference for exhibits about radio and electricity, aeroplanes, machinery, etc. This preference is also shown on the senior level with a greater spread of specific interests. The girls prefer the biological exhibits, especially those on health and disease, physiology and animal life. They are less interested than boys in physical sciences though their interest increases on the senior level. The miscellaneous exhibits involved several areas of applied science or non-scientific material, which was neither clearly biological nor physical science.

Questions on school studies showed that over 90 per cent of the exhibitors in junior high school had taken general science or biology. In the senior high school the majority were studying chemistry or physics. These courses are the ones usually offered or required at these different grade levels. Science courses were preferred by a strong majority of the exhibitors to all others. Their preferences also indicated sex differences.

SCHOOL SUBJECTS PREFERRED BY FAIR EXHIBITORS

School Subject	Boys No.	Boys Per cent	Girls No.	Girls Per cent
Biology	35.5	19	13	35
General Science	45.5	24	4	11
Physics	13	7	0	0
Chemistry	14.5	8	4.5	12
Other Sciences	8.5	5	1	3
Non-Science subjects	71	38	14.5	39
Totals	188	101	37	100

Next to science, mathematics was a preferred subject. The only other subjects which received a preference worthy of note were history and art.

Seventy-three per cent of the boys and 68 per cent of the girls interested in science worked in the school science laboratories outside of class hours. Most helped the science teacher in cleaning up apparatus, setting up experiments and other tasks. Working closely with the science teacher in the laboratory gives these adolescents opportunities for informal instruction and guidance far in advance of their classmates. Seventy-nine per cent of the boys and 86 per cent of the girls felt that

[3] Detailed tabular data on this and other topics which follow appear in Chapter XI of the report.

they did not have enough time to spend in the science laboratory and would have liked to have more. Eighty-eight per cent of the boys and 68 per cent of the girls spent their own time on voluntary science activities outside of the school. This included research, experimenting at home, field trips, participation in science clubs and reading. Sixty-three per cent of the boys but only 25 per cent of the girls had a place at home where they could experiment. The places included corners of the basement, attic, or kitchen, or the adolescent's own room where some kind of laboratory or work-bench had been erected. Homemade apparatus was constructed and in many cases all extra money was spent on equipment for these home laboratories.

When asked "What would you like best to do in science?" the exhibitors gave replies characterized by a wide variety of specific statements. Their interests in science were usually so advanced that they gave such replies as "Experiment with ductless glands. Investigate ultra-violet light. Find out about atomic structure. Study fluorescent minerals. . . ." Fifty-one per cent of the girls desired to do work, which might be classified as biological science: 20 per cent of the boys were interested in this area. However, 35 per cent of the boys preferred work with radio, electricity, aeroplanes, etc. (physical science) but not a single girl wanted to do this type of experimentation. Boys favored work in chemistry 17 to 3 per cent and girls preferred astronomy 15 to 13 per cent.

Adolescents interested in science may work alone but often they carry on their experiments with some friend or relative. Over 50 per cent reported that their science teacher helped them with their work. One exhibitor reported that his science teacher gave him money to buy the materials he needed. More often the exhibitors reported that these adults assisted morally. They "strengthen my ambition" reports one . . . . they "answer my questions" and "offer suggestions and criticism." Occasionally technical help is available as the boy who reported help from his father who is "a good mechanic."

Seventy-five per cent of the boys and 76 per cent of the girls consider science their chief interest. This interest was closely connected with preferred occupations. Eighty-one per cent of the boys and 66 per cent of the girls wished to engage in scientific or related work. The details of their choices indicated how specific their wishes were. Boys listed 67 vocations (48 of them scientific). Girls listed 20 vocations of which 14 were science or applied science. The replies also indicated economic and other considerations as well as an interest in science. All adolescents did not look for professional occupations which carry high prestige and remuneration.

MEMBERSHIP IN SCIENCE CLUBS

	Boys		Girls	
Grades 7–8–9				
School Clubs	No.	%	No.	%
Members	28	78	2	67
Non-Members	8	22	1	33
Non-School Clubs				
Members	6	20	1	33
Non-Members	24	80	2	67
Grades 10–11–12				
School Clubs	No.	%	No.	%
Members	37	67	10	72
Non-Members	18	33	4	28
Non-School Clubs				
Members	13	27	4	33
Non-Members	36	73	8	67

Collections made by science-interested adolescents were predominately scientific. They included such things as insects, rocks, chemicals, model airplanes, alloys, etc. The types of collections made by boys and girls differed; the differences being similar to those expressed through other channels. The majority of these adolescents worked on their collections for a year or more—often for more than three years. Membership in science clubs is exceedingly important for science-interested adolescents. The majority were members of clubs in their school. A smaller percentage were mem-

bers of clubs affiliated with museums and other institutions. Membership in these two types of clubs did not usually overlap. The replies suggested that over 90 per cent of the adolescents interested in science were members of science clubs and were active in the club activities. Meister has indicated the educational value of such club work in terms of factual learning. Other educational outcomes are of even greater importance. These science clubs must even now be considered a fundamental source of these adolescents' science education.

The data from the 1937 questionnaire give some interesting information about the age at which these exhibitors first became interested in science. These data are from 16 girls and 88 boys:

Became interested		
after age of 12	31%—girls	9%—boys
through age of 12	69%—girls	91%—boys
between 10 and 12	51%—girls	61%—boys

While these limited data can only be suggestive they indicate that these very significant interests tend to become fixed at a pre-adolescent period, usually between the ages of 10 and 12. If this is so, the fact should be very important in science education. Present practice includes little or no education in science at this age level.

Another question asked the exhibitors what they considered their outstanding ability. Twenty-two per cent listed some habit or power such as ability to learn, mental power or concentration. Thirty-six per cent listed scientific skill or technique. When asked to list their heroes, 71 per cent of the boys and 64 per cent of the girls listed scientists. Pasteur was the outstanding hero of these adolescents. Edison, Einstein, Lindbergh and Koch were frequently mentioned. Eighty-two per cent of the scientific heroes were workers in the field of biology or physics. The exhibitors were given opportunity to indicate the kind of scientific questions they wondered about. About 25 per cent wondered regarding questions of astronomy. About 18 per cent regarding physical science and 35 per cent about biological matters. The astronomical questions were of such a nature as to indicate that this form of wondering probably served as an escape mechanism for the adolescent. The biological questions strongly indicated personal problems in relation to growth and reproduction. The wondering of these adolescents interested in science was almost identical with a larger group of unselected adolescents.[5] When asked to list things which were at present impossible, but which they hoped science might accomplish in the future, the exhibitors replied with a great many specific items. Transportation communication and health seemed to be the outstanding areas of desired improvement. Only a few replies indicated awareness of the social and economic implications of these desired improvements.

Fifty per cent of the boys and 62 per cent of the girls felt that people were happy. The question continued to ask "What do you think science can do to make people happier?" Replies to this question were so individual that no attempt was made to summarize the data. Five replies, selected at random, will illustrate the type of replies:

1. By eliminating diseases and perfecting labor saving devices.
2. Science can give clean well-built houses and better sanitation but I believe that nothing can make everybody happy. There is always somebody who is discontented.
3. Inventions and discoveries in medicine will make life easier for most people.
4. Explain some of the mysteries of life. Teach them how to live and raise happy, healthy, intelligent children.
5. Save our forests and wild life so that people may have some retreat where nature is in the raw.

These samples illustrate the wide variety of responses. The conquest of disease is an important item mentioned by many exhibitors. There was frequent mention of "making life easier" in various ways and

[5] Zim, Herbert S. *Loc. cit.* Chapter VII.

some direct comments on distribution of wealth. A few mentioned the value of science in giving "a philosophy of life" and as a means of "broadening interests." Reduction of crime, eradication of slums and other social evils were mentioned.

These questionnaire replies can only throw a superficial light on the characteristics of adolescents who are interested in science. Certain obvious effects of the science interest on activities are easy to notice. The more subtle effects on personality, thought and emotions can only be inferred. A further clue as to the significance of a science interest was obtained from the autobiographies written by the exhibitors. Of a total of 111 autobiographies submitted, 20 were selected and reported in detail, to illustrate the meaning of a science interest to the writer. One example is a boy 14 years old who shows a science interest closely related to curiosity about reproduction and personal problems. A 17 year old girl, who is a junior in high school, finds science an outlet "for my restless nerves." Her case illustrates the role of a predominating interest in music. Another junior in high school aged 16 has an interest in chemistry closely associated with his vocational ambitions. The autobiographies even more than the questionnaire information indicate the meaning of a science interest to an adolescent. For one boy it may mean a job, to another a chance to aid humanity, to a third a means of understanding himself and to a fourth a way to follow the pattern of a man he admires. For each of these adolescents the science interest is *specific*. It is related to a definite field of science and the adolescent has a clear idea of how he wants to proceed. For each the interest has a definite and important role in his total growth and the development of his personality. Each adolescent's science interest is of enough significance to be considered in educational planning and guidance.

The most outstanding characteristic of interested adolescents is that they work long and continuously on the topics which have their interest. They give freely of their time and energy, often to the extent of curtailing other desirable activities. They prefer school subjects associated with their interest, or those in which they can indirectly make use of the materials which interest them. These adolescents will dislike school subjects, which they do not see related to their interests. Of all the subjects in the curriculum, science or some phase of it, is preferred. They do not seem able to get enough of science in their classes, though many of them are now studying science and have taken as much science as their school programs permit. Besides their work in class, these interested adolescents spend a great deal of time in the science laboratories outside class hours. They assist the teachers, work on special projects or may just "hang around." Often they are members of "laboratory squads" with definite duties in the care of equipment and setting up of apparatus. This extra time in the laboratory permits them to have closer contact with their science teachers and to gain much from these informal contacts. These adolescents feel that their science teachers are the ones who help them most with their interest. This help and guidance are often of vital significance to the adolescent. Others besides the science teacher give assistance, but usually in a minor role, outside of school.

In school these adolescents are members of science clubs. Frequently they are elected to office and take on additional responsibilities. At meetings they give talks and demonstrations, prepare exhibits or participate in research projects. Through the club activities they frequently explore fields of science beyond those usually covered in classes. In many cases the work in a club might be considered equivalent to a college course in optics, histology, electricity, etc. The school club serves an important educational function for the science-interested adolescent.

Outside of school the science interest of these adolescents continues. Many carry on their work at home or in clubs connected with museums and other organizations. These adolescents spend a large part of their free time each week on science activities. They are constantly reading scientific books and magazines, visiting museums, taking field trips, etc. Many find the opportunity to build a laboratory or work-bench at home and continue experiments there. In doing this they ingeniously devise simple apparatus and equipment. Much of their spending money goes to the purchase of materials and supplies. They may work alone or with a friend. Often this work goes on in spite of the objections of distracted parents, who are unaware of its significance to their children.

Most of the adolescents who are interested in science have become interested before the age of 12 and have been persistently interested since. They do not usually shift from one field of science to another. Both boys and girls collect scientific specimens and tend to develop their collections over several years. These young people do not exhibit a general interest in science. The focus of their attention is directed to specific topics or problems which they are trying to understand and with which they desire to experiment. This specificity is evident in the work they have done, the exhibits they have prepared, and in their statements of things they would like to do. Their vocational preferences lie within the field of science and those who are exceptions express strong desires for scientific hobbies.

The ambitions, hopes, ideals, and wishes of these young people are affected by their interest in science. Many express a strong urge to benefit mankind through their participation in some branch of science. They feel that science can accomplish great things in the future and that it can do much to improve the conditions of man. Their heroes are mostly scientists and it is frequent that the emulation of these men has guided their activities. Within the limits of their age and understanding they are cognizant of some of the implications of science, though often their thinking in this direction is superficial.

The adolescent interested in science may come from a variety of social or economic backgrounds. His interest may have no relation to the family background or the occupations of his parents. Family conditions may be such that the adolescent soon realizes that he cannot carry on his education to the extent he desires and that he must compromise both his vocational ambition and his hobbies. Especially, in the case of girls the adolescents seem conscious of the forces which limit the expression of their interest and the fulfillment of their wishes in this respect.

The interest in science which differentiates these adolescents from others brings with it deeper and different satisfactions than other adolescents may feel. It may bring the adolescent closer to adult life, in some respects. The interest in science also brings new problems to the adolescent, new adjustments and decisions to make. The effect of all this on his total growth is difficult to see, but only through knowing the effect of his science interest on all other aspects of his living, will we be able to help the adolescent make the best use of this interest drive.

AN EXPERIMENT IN THE USE OF FREE READING IN GENERAL SCIENCE *

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THE PROBLEM

The consensus of opinion among educators that extensive reading is a stimulus to pupil interest and the fact that many teachers have used this activity to enrich the general science program leads to the question of alloting time for its usage. Since there exists a wide variation of opinion among science teachers concerning the amount of class time that should be used for stressing free reading, the purpose of this study was to devote at least one-fifth of the class time to reading and then to compare the results with those when the traditional method of teaching science was followed.

MATERIALS AND TECHNIQUE

This study was conducted at the Horace Mann High School, Salt Lake City, Utah, and extended over eight months of the regular school year. One hundred and fifty-two pupils were involved in this study. This number comprised the larger part of four ninth-grade general science classes with approximately the same number in each.

Two of the classes were selected for the experimental group and the other two were utilized as the control group. All four classes were taught by the experimenter and for four periods each week they were conducted in the same manner. During the remaining period, the experimental classes followed the extensive reading program.

The subject matter consisted of the same units for both groups, but because of the reading activity, the experimental group did not spend as much time on detailed discussion as did the control classes. The reading material used was selected from a list of books recommended by the textbook authors and previous investigators in this field. Many scientific magazines and newspaper clippings supplied interesting reading matter.

The achievement of pupils in the acquisition of scientific facts and principles was measured by forms A and B of the Ruch-Popenoe General Science Test. Form A was given at the beginning of the study and Form B was given at the close. From the scores made on both tests, the achievements of pupils in terms of point score gains were obtained. Science tests of the true-false completion and matching types were used to measure achievement in each unit covered.

For the purpose of comparing outcomes, pupils in the two groups were paired. The matching process was done as carefully as possible with the number of pupils available. The basis for matching was sex, intelligence quotients, and point scores obtained from the Form A General Science Test. The sex and intelligence quotients were considered first. A difference of four points in intelligence quotients was arbitrarily selected as a maximum when the pairs were chosen. In order to make the number of pairs as large as possible and still not influence the reliability of the matchings, a variation of seven points was arbitrarily selected as the maximum difference in science test scores. Whenever possible, the chronological ages were considered in pairing and in some instances, the types of pupils were determining factors. Examples of this were matchings of pupils of the same nationality and pupils who seem to have the same reading tenden-

* A digest of a Master's Thesis, University of Southern California.

cies. Forty-eight pairs were secured from the two groups. Pupils who were not paired were not considered when objective results were treated, but all were included when subjective results were discussed. Special permission was secured from the author to use the "Test for Scientific Attitudes," for the purpose of comparing the development of scientific attitudes in the two groups.

FINDINGS AND CONCLUSIONS

The gains in point scores as shown by a comparison of the individual scores made by pupils on both forms of the science test revealed the following facts. The gains varied in both groups from approximately twenty-four as a maximum to five as a minimum. The mean for the gains of the experimental group was 10.04 and the mean for the gains of the control group was 10.5. These results gave an average gain of .46 points in favor of the control group. The mean for the experimental group on the Form A Test was 20.31 and for the control group 20.62. The mean for the experimental group on the Form B Test was 30.21 and for the control group 30.97. The difference in means in all cases indicated that the control group was slightly superior as measured by the tests. However, in no case, did the difference in means have any statistical significance. When each pair was considered, it was found that twenty-two pupils in each group had higher gains than pupils with whom they were paired, and in four matchings, the gains were the same. The boys in the control group showed a higher average by .45 points than the experimental group. The girls in the control group showed a higher average by .38 points than the experimental group. When the average for the boys and girls of the experimental group were compared, the boys showed a superiority by 1.67 points. The experimental group was .92 points higher than the control group in scientific attitudes, but no statistical significance was found.

Since the purpose of the study was to secure information which would help in making an estimate of the time that may profitably be given to free reading, the results of the tests, questionnaires, and personal observations of the experimenter may be summarized as follows:

1. The difference in the gains in scientific facts and principles was not large enough to show any significant advantage for either group.
2. When the gains for both sexes of the two groups were compared separately, it was found that neither sex showed superiority in learning and retaining factual information.
3. Although the mean score of the experimental group was slightly above that of the control group on the Scientific Attitudes Test, neither group showed an advantage in the acquiring of scientific attitudes, as measured by the test available.
4. The low scores made by both groups on the "Test For Scientific Attitudes" was supporting evidence to show that scientific attitudes should be taught directly if they are to be outcomes of science teaching.
5. The pupils belonging to the experimental group made an effort to obtain books of their interest and they read extensively when given the opportunity and encouragement.
6. Pupils were willing and eager to comment on interesting books they had read.
7. A large percentage of the experimental group expressed the feeling that extensive reading was a help to them in learning facts in general science.
8. A majority of the reading group indicated that they would wish to follow the same reading program if work of this nature was to be covered again.

When the information obtained from this study was carefully considered for the purpose of making conclusions, some of the outstanding weaknesses were made evident. In the first place, the scope of the study was unquestionably limited. Since only four classes in science were available, the small number of matchings with which the experimenter was working was one of the principal limitations. An adequate supply of reading matter in the school library was an obstacle which may not have been completely overcome. Although the tests used for measuring achievement were unquestionably reliable, it should be remembered that they were constructed to measure objective results and did not at-

tempt to show outcomes of a subjective nature.

Recognizing these limitations only tentative conclusions are justified. The following are offered:

1. A free-reading program in ninth-grade general science extending over a period of eight months and occupying one-fifth of the class periods did not detract from the ability to learn and retain scientific facts and principles.

2. Pupils taking one period each week for extensive reading will develop scientific attitudes at about the same rate as pupils spending all their time following the contents of one or two textbooks.

3. An extensive reading program makes possible individual selections of reading matter and so provides for individual differences.

4. Free-reading activities help pupils become more self-reliant in making new selections.

5. A well-organized free-reading program provides an opportunity for pupils to select and read science books of their interest and, incidentally, it helps them to become better acquainted with the facilities and services of the school and public libraries.

7. An extensive reading program encourages pupil activity and initiative while the teacher acts in an advisory capacity.

Because of the limitations of the experimental study, the experimenter does not feel capable of making specific recommendations for the use of extensive reading in science teaching. In the absence of recommendations, some suggestions are offered which may assist teachers attempting a free-reading program. In the first place, some time and effort can profitably be given to extensive reading in all classes in general science. The time used should vary with the amount of reading matter available and the interest shown by the pupils. The reading activity should start after the majority of the pupils have felt the need for the investigation of a broader field of interest and information. The time taken for reading may be even greater than that used in this study provided it is done for a purpose clearly understood by the pupils. The reading matter should be selected by the pupils under supervision of the teacher after definite goals have been set up.

GESTALT PSYCHOLOGY AND THE TEACHING OF SCIENCE

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Many educators are raising the question, "What shall we do with science?" Although numerous answers have been given to this question, no one appears to have the answer. What has brought about this problem? The present paper will point out two sets of background factors in the problem of science teaching. One of these sets of factors is methodological, the other deals with the psychology of learning.

METHODOLOGICAL CONSIDERATIONS

The scientist of the 19th and early 20th centuries for the most part relied upon conceptions of scientific methodology as a general guide to the training of young people in science. It was his belief that if he trained the student in "the scientific method" that the major objective of the study of science had been met. That this objective is a fundamental one few would doubt, yet the problem of how to achieve this objective became the real question. In this connection science teachers have debated laboratory methods *versus* demonstration methods *versus* lecture methods *ad nauseam*. Through all of this the question, "What is the scientific method?" was ambigiously answered. Yet this question would appear much more fundamental than the debate over techniques to achieve "the scientific method."

Recent years have witnessed some very far-reaching changes in our conceptions of "What is scientific method?" Consideration of the history of scientific methodology

reveals certain rather curious misunderstandings. Beginning with Bacon and reaching a climax in Newton physical science became inductively minded. Newton, in discussing methodology in his *Principia,* had used the phrase, *hypotheses non fingo.* This became the center of the new methodology. It lead to the hardboiled scientific view, namely, that a reputable scientist carries out experiments and after performing a large number and repeatedly checking the observations, he may form an hypothesis, then a theory, then a law. However, the forming of theories was always a somewhat questionable activity—was often labeled in a derogatory way as "philosophy." In any case, the student was to be trained in observing facts.

Biology in its effort to be a science modeled its methodology after that of physics. Louis Agassiz sent his students to some one animal form to learn how to observe the facts of anatomy. Over and over they observed until they were qualified scientists. The Russian physiologist, Pavlov, expressed this view when he said that after twenty years of experimentation he formulated a theory. Psychology and education in turn patterned after physics and biology in an effort to gain the halo of "science."

Recent considerations would tend to demonstrate that this hardboiled inductive approach was based on an historical myth. Careful study of the methodology of Newton and Bacon proves that they had no such pure induction in mind. If the physical scientist had bothered to read Newton's *Principia* he would have found that Newton specified explicitly in his preface what he meant by *hypotheses non fingo.* He had reference to the armchair framing of theories that had characterized the theologian's approach to science. He was not opposed to hypotheses as such. In fact, the first two books of the *Principia* were based upon hypotheses, as relativity physics was to point out a century or more later.

Bacon did not advocate the performing of just any experiment. He spoke of critical experiments, experiments that would unambiguously decide between several alternative hypotheses or theories.

All that the hard-boiled inductivist succeeded in doing by refusing to admit that he had hypotheses, theories and hunches was to let uninspected hypotheses and theories influence his experimentation. Poincaré pointed out in his *Science and Hypothesis* that "an accumulation of facts is no more a science than a heap of stones is a house."

Thus in recent years a new methodology has developed which is partly inductive and partly deductive, called a hypothetico-deductive method. This method emphasizes the importance of thinking in science as well as experimenting. The double checks of logical consistency and experimental verification are employed. Before considering what this new methodology means for science teaching an examination of newer conceptions of learning is appropriate.

LEARNING AS A FUNCTIONAL PROCESS

As a result of the influence of Gestalt psychology and the functional movement of Dewey and Bode our conceptions of the nature of the process of learning have undergone radical changes in the last few years. These changes may be summarized under five points.

(1) *The directional character of learning.* Human beings strive to reach ends. Their behavior is goal-seeking; is purposeful. This fact is not, however, unique to human beings, but appears to be analogous to the action of any energy system. In physics an object moves toward equilibrium —a remote end in the future of the object. In biology there are metabolic equilibria such as Cannon's homostasis, ecological equilibria, *et cetera.* In fact, for action to take place at all, a remote end is necessary (e.g., Eddington's lead-term). Learning then depends on a remote end, a future equilibrium or in human descriptive terms, on purposes, needs, goals, interests. Thus

where the learner sees a definite objective, learning is rapid; where he has a vague objective, learning is slow or does not occur at all.

That students of secondary science have goals and purposes with respect to the general domain of science, every study of interests from the junior high to college has shown. Yet these same students have difficulty with science as a subject. Apparently the purposes of the student have not coincided with the purpose of the instructor. Obviously, it is the student's purpose that the science teacher must employ as a base for a program. This does not exclude guidance of purposes and goals; such a process is one of the major functions of the teacher. But the goals, interests, needs which the student brings with him to the science study must be the base for such guidance.

Two studies conducted under the author's direction may serve to illustrate these points concerning interests and goals. The first study was carried out with 359 Junior High Schools boys.[1] Table I shows the interest-patterns exhibited by this group. Significant is the fact that whereas only .21 per cent showed an interest in science, over 60 per cent professed an interest in subjects that fall within the general domain of science (starred items in Table I). The wide difference between interest in science subjects and interest in science as taught should offer a real challenge to science teachers.

The second study was carried out with 1,263 high school students. They were asked to rate twenty outcomes of high school education in terms of great, average, slight or no importance to them as students. Four of these items related to science. Table II shows the ratings of these students.[2]

TABLE I

INTEREST-PATTERNS OF 359 JUNIOR HIGH BOYS

Subject	%
*Aviation	20.5
*Hunting and Fishing	14.8
Woodwork	11.2
*Radio	8.9
*Electricity	7.5
Athletics	7.5
*Model making	5.9
*Engineering	4.7
Government Service	4.2
Questionable	3.9
Business	2.8
Stamp Collecting	2.8
Riding	.8
*Architecture	.5
*Mechanics	.5
*Medicine	.5
*Archaeology	.21
*Science	.21
Map making	.21
*Diesel Engines	.21
Contracting	.21
Music	.21
Typing	.21
Printing	.21
*Taxidermy	.21
Art	.21
*Astronomy	.21

(2) *Level of maturity and learning.* The learner is able to solve a task when he has reached the appropriate level of maturation. This maturation process includes growth of structural form and development of function. It results from external and internal stimulation. In many instances selection of a task which is adjusted to the learner's level of maturation results in learning in one trial. Drill is necessary when the maturation level of the learner and the complexity of the task are out of adjustment. In a sense, then, an extended learning curve with plateaux is a measure of the degree to which the teacher guessed wrong concerning the learner's

TABLE II

Item	Judged average to great importance %	Judged of slight or no importance %
Physiology & Hygiene	90.3	9.7
Importance & Function of Sex	86.9	13.1
First Aid	91.5	8.5
Elementary Psychology	72.5	27.5

[1] The author is indebted to Mr. Lee C. Noderer of National City, California, for these data.

[2] The author is indebted to Mrs. Dora L. Lutz of Santa Ana, California, for these data.

capabilities. Not only does inefficiency result from failure to adjust maturation level and task, but the learner may develop adverse emotional patterns toward the task, toward the subject, and in some instances toward the whole school. The learner is discouraged, lacks confidence in his ability to master the task, hates the task, the teacher, *et cetera*. Many of the statements of adults that they do not have a "mathematical mind," a "scientific mind," a "musical mind," are based on this lack of adjustment of difficulty of task to the maturation level of the student, leading to an emotional blocking toward the task and subject.

(3) *Insight and meaning in learning.* It is a trueism that the more meaningful the material to be learned the more rapid the learning. Yet many teachers have failed to take adequate account of the meaning of the material for the learner. Material which is highly meaningful for the instructor may be nonsensical for the learner. When the task is adjusted to the learner's level of maturation, the learner will comprehend the solution to the task with a flash of understanding or insight. There is a similarity between this rediscovery by the learner and the discovery of the mature scientist. Usually such a discovery or re-discovery is so important to the person that he wants to share it with others; he is enthusiastic unless stifled by tomb-like classroom discipline. The informality of a laboratory is perhaps its greatest asset for efficient learning.

Numerous studies show us that memorized detail, possessing little meaning for the student, is lost very rapidly through forgetting. Whereas material that is rich in meaning, that is comprehended in terms of its general principles as well as its details, is retained over a long period. Such a procedure is the basis for carry-over to new problems, both in and out of school. The experience of a secondary school physics teacher following the Long Beach earthquake will serve to illustrate these points. It was considered unsafe to enter the school building to use the physics laboratory or even to secure the equipment. The class met in a tent. The teacher asked each student to bring any odds and ends of wire, tin cans, or other usable material that he could find at home. With this collection of "junk" the class built what apparatus they needed. The instructor pointed out that the material was more meaningful to the student than it had ever been in the rather well-equipped physics laboratory. There appeared to be greater carry-over value in this situation.

(4) *Learning and the whole-part relation.* The Gestalt theory in psychology has emphasized the necessity of considering the total person behaving in a total environment. The teacher must be cognizant of the social, emotional and physical development of the student, as well as his intellectual development. Since the student responds to his total psychological environment, the relation of one subject to another in school, the relation of school to home, to community, to friendship groups, all become of great importance. Learning of one task does not take place in a vacuum, but rather in a complex environment.

The biologist will recognize similarities here to the organismic theories of Child, Weiss, Rudy, Coghill, Bernard. Child's emphasis on the unit of total organism in its environment is the biological phase of this problem. The physicist will be reminded of the field theories in physics.

In learning, then, we see the importance of cooperative curricular approaches, not only within the science fields, but throughout the school curriculum and between the school and the community. The question should be "What can science contribute in the total lives of young people?," rather than "What should the young person know about science?." Reference again to Tables I and II will illustrate this point.

That the whole-part relation offers a fruitful basis for a consistent curriculum,

the scientist will have little difficulty in comprehending; teachers of other subject fields, where the relationship is less obvious, but none the less present, must be convinced by the science people.

(5) *Progressive differentiation of learning.* The biologist needs little reminder of the importance of progressive differentiation from gross structural form to unique detail, from gross movement to skilled movement. The studies of Child and Coghill have amply illustrated this factor in the development of organisms. In like fashion, the young child seems to develop in this uni-directional way. Similarly, the learning of a new task appears to go from the general, the gross to the specific and the detailed.

In this connection the distinction should be drawn between the concrete illustration of a principle and the presentation of a fact without recognition of the differentiation process. At the beginning of the study of a subject, the learner needs to have a task which is concrete and represents a specific goal. Yet he also should have a general understanding of the principles of the subject that can be illustrated by this concrete task. He can then proceed from the general understanding of principles, as illustrated by a specific case, to a more detailed understanding of principles, illustrated by more abstract cases. In this fashion it is possible to differentiate a gross understanding pattern, but begin with the learner's vital and actual problems. This represents both a logical and a psychological order of treatment of science. The student can in this way differentiate his knowledge of science in two dimensions. First, through increasing specificity of detail; second, through an expansion of his understanding of the principles underlying science.

It would appear then, that the teacher of science has a rather unique opportunity. The reappraisal of the history of scientific methodology and the information concerning the learning process are highly consistent with one another and with recent developments in biological and physical science. It need no longer be true that

> "(i) Science, but no scientific method, is taught to science students,
>
> and
>
> "(ii) Scientific method, but no science, is taught to a small proportion of arts students . . ."
>
> W. H. George
> *The Scientist in Action*, 1938

A SCIENCE COURSE FOR TENTH-GRADE PUPILS

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"What good is it going to do me?" This is the question that many pupils are asking who are enrolled in the traditional science courses of the senior high schools. What answer can they be given? General science, as a broad overview of the field, serves its purpose well for all pupils in the junior high school; but for pupils who have only average or below-average ability there is in many schools no adequate science course for the grade above.

Science teaching is missing one of its greatest opportunities if it fails to meet at least some of the needs of the average worker of tomorrow. Both the home maker and the wage earner are concerned vitally with everyday choices of goods, services, and methods of thinking, but they obtain little help from the usual science content. To many, especially those who will not go to college, the term "good" is applied to knowledge for which they can see an immediate use. In commerce, goods are made to fit definite needs, are

sold, and then used; the same should be true of subject matter in the classroom. High-pressure salesmanship may make the sale, but it cannot overcome the dissatisfaction of the buyer who can find no use for the product.

In general, curriculum material exists for the cultivation of worth-while appreciations and for the instillation of clear methods of thinking. Along with these go the mechanical skills and practical applications. Just how proficient are we as science teachers in determining a balanced ration of these essentials for our varying groups? The college-preparatory pupils see readily enough why they need to become skillful in the use of laboratory equipment, in drawing specimens under the microscope, or in solving difficult problems. These tasks are foundations for future work and as such demand and get attention. In similar situations non-college-preparatory members visit with their neighbors, look out the windows, contemplate their finger nails, or comb their hair. They are present physically but absent mentally.

In various school magazines during the past few years an integrated science course for the senior high school has been under consideration. There is general disagreement, however, as to whether such a course should be terminal at the end of one or two years, whether it should be a fusion of the practical parts of all other science subjects or of only two or three of them, and whether it should be planned to suit the needs of pupils of average or above-average intelligence. Thinking seems not to have crystallized sufficiently to provide either courses or textbooks along a given line that stimulates any great following of teachers. Certainly we need more thinking, more discussion, and more tryout courses of this general type if science is to maintain its place in the program of studies.

New names and slogans are the advertisers' stock in trade; educators seem to like them too. The nineteen-thirties made much of "Consumer Education," which is only another name for courses having practical values for the layman. Consumer science on paper looked easy because it was assumed that the laboratory could be utilized as a testing place for possible purchases. Tryouts proved this impossible because not enough simple tests could be devised to determine comparative values of goods. In addition, immature minds were apt to reach wrong conclusions from such tests. Whatever such a course is named, it cannot hope to impart information concerning specific products.

The schools of Flint, Michigan, have tried for years to determine what science information can best serve the needs of its tenth-grade boys and girls who will not go to college. The tenth grade was chosen for the course because of the drop-outs following this age level. Titled "Modern Science," a course has finally evolved from a fusion of biology, chemistry, physics, and health education. From these subjects, we have been able to draw a great many practical applications to fit the industrial community in which we live. Due to the fact that everyone entering the senior high school has covered very well the units pertaining to other science subjects, such as astronomy and weather and climate, it was decided to omit them. Any material which since has failed to interest the majority of pupils electing the course has also been eliminated. Pupil questionnaires as a method of learning which units are liked best or least have been unsuccessful in determining content. However carefully worded and administered, the questionnaires always revealed the same reactions—the class liked what the instructor liked and could teach with enthusiasm.

The subject matter in the course, while treated very simply, is still adult in character. All semblance of talking down to the pupils is avoided. For example, enough chemical symbols and formulas are taught to express a few important reactions such

as those of starch-making and the oxidation of carbon. Pupils seem to derive as much satisfaction from their ability to put symbols together correctly as they get from speaking a sentence of a foreign language or of playing a melody on a musical instrument. They like to attain the grown-up level of taking chemistry even though they can master only the very easy parts of it.

Broad general topics such as oxygen and oxidation were first chosen and afterwards broken down into problems closely touching the individual. After some phases of the chemistry of oxygen is discussed, the problem of maintaining the oxygen-carbon dioxide balance in nature is considered. The biology of food manufacture is a next step, with the oxidation of foods and fuels a further outgrowth.

Proper choices of foods in relation to health including the use of vitamins, and the avoidance of foods to which one may be allergic is a part of the food study. Sanitary handling of foods, the avoidance of doubtful preservatives, the advantages and disadvantages of using canned goods, and the bases for grading foods are also included.

Oxidation of fuels is concerned with the types of heating plants and the energy content of the fuel. In order to get maximum value in buying fuels, a number of factors must be considered such as the size of the house to be heated, the amount of ash in the fuel, its cleanliness of burning, its relative cost, safety of the fuel from explosions, and the space for storing. Economy of fuels used in transportation, especially economy of gasoline in the automobile, is another phase for discussion.

After food and fuel, doubtless there should come something about the choosing of clothing. Health, hygiene, and the wise expenditure of income may all be tied into this unit. Boys as well as girls often choose the shoddy only because they have not been trained in discrimination. Excellent films for teaching purposes may be obtained from manufacturers of clothing and shoes for only the cost of transportation.

Following clothing, general cleanliness is perhaps of next importance; at least it seems to be in a factory town. Water softeners and soaps, cold creams and nail polishes, gargles and tooth pastes, hair tonics and deodorants are all topics which this group of pupils finds interesting. Since pupils are already making their selections from the various brands of such commodities for their personal uses, they should be given some guidance in what to buy.

There are many areas from which to choose the content material for such a course; but the selection of units must, of course, be governed largely by their probable usefulness in the locality in which the course is taught. Among such units will perhaps be found those concerned with automobiles, houses, and electricity. The operation of a car from both the standpoint of safety and of economy touches the lives of most people today. It is less vital, however, that pupils learn the four strokes of a piston than that they understand the safety of car operation. Knowing the different parts of an automobile engine is not of so much importance as is the realization of the need for frequent checking of tires and brakes.

After the units to be included in the Modern Science Course at Flint had been selected, attention was directed to the methods of presentation. A relatively small number of major generalizations was determined and each assignment was built around one. To effect a clear understanding of a generalization is the major goal of every lesson. Such simple generalizations as, "Oxygen which is removed from the air by oxidation is constantly being replaced by green plants," are easy enough for the pupil to understand. It is the task of the teacher not to give the generalization, but to present the material in such a manner that at the end of the lesson the pupil may write it in his own words as a summary of the work done. Only enough,

if any, of the pure theory is given to clarify the generalization. Problems, if required at all, are very simple both as to statement and as to application.

Training in scientific attitudes is a definite part of the work. It is hoped that sufficient transfer of these will result to protect the buyer who is inclined to be swayed too far by claims of the advertiser. They are expected also to stimulate a defence of advertising that is too severely criticized. Learning situations are provided in which pupils are lead to understand that all advertising is not bad merely because a part of it misleads, and that business is not to be condemned because simply it is "big" business. This point is clarified by indicating that it is the large firms which can afford to pay for the research necessary to supply us with improvements in our way of living.

To maintain interest there is a plentiful amount of time spent in the laboratory but a minimum requirement of "writing up" experiments. Whatever is discussed in the classroom is followed through as soon as possible with whatever simple tests can be made to illustrate the point. In addition, all possible visual aids are used as supplementary material. We do not strive to make the course easy from the standpoint of doing the work for the pupil but rather strive to give him work to do appropriate to his skill and comprehension.

How does this course differ from that of the general science in either the junior or senior high school? (1) It places the emphasis on choices whether they be of goods, services, or methods of thinking. (2) It takes for its subject matter that which is adult in character yet which is on a level with the average or below-average intelligence of the tenth-grade boy or girl. (3) It provides material for which these pupils may have both an immediate and a future need.

PRINCIPLES IN THE FIELD OF LIGHT NEEDED TO INTERPRET GENERAL LIFE SITUATIONS

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This study has been made by the author with the view to making a forward step in the direction of bringing the whole program of science education in general, and of that portion of the teaching of physics dealing with the principles of light in particular, into a closer relationship with the present and future daily activities of our high school pupils who pursue the study of science. Hearty and enthusiastic cooperation was freely given in this undertaking by outstanding educators, lighting experts, and others engaged in technical and professional pursuits calling for wide applications of the principles of light and lighting. The free expressions of those representatives of the professionally and technically trained men reveal that they feel the need for decided revision of our present high school science courses.

Dr. Henry Harap, George Peabody College for Teachers, in a letter to the author says that he in sympathy with the view that science teaching should be closely related to the needs of living and that the items in the check list used in this study could be well recommended for use as a basis for building a science course. Dr. Miles A. Tinker, Professor of Psychology, University of Minnesota, states that it is obvious that the practical information gained from the average physics book is scanty, and that there is much room for improvement. Dr. Tinker has rendered a

valuable service in giving sound interpretation of the principles and findings of extensive lighting researches. Walter Sturrock, General Electric Company, offers the comment that some of the physics textbooks now in high school use contain out-of-date information on lighting principles and the applications of these principles. These statements are merely samples of the many gathered by the author for the purpose of verifying or refuting his theory that the present teaching aids in the field of light were insufficient to cause valuable and fundamental principles of light and lighting to become functional and dynamic in modern daily-life situations.

It is evident that the theory was verified, and the study of the daily needs of adults for the understanding and use of the principles of light was then undertaken.

The purposes of this study were: (1) to compile a check of these principles in the field of light which appear to have definite value to adults in interpreting their daily experiences; (2) to determine by means of the frequency of their needs what understandings have definite value in successfully solving the problems and efficiently performing the tasks encountered in the daily activities of adults; (3) to determine the relation between the predictions of specialists and teachers, and the actual findings as to the frequency of the needs of these understandings by means of a survey; and (4) to arrive at certain conclusions in regard to the value of the principles in the field of light as a basis for curriculum reconstruction in high school physics courses. From this and similar studies it should be possible to reach valuable conclusions which should be guiding principles in the successful reconstruction of the high school curriculum. The analysis of understandings needed in adult activities should serve as a basis for more closely relating in-school experiences to out-of-school experiences. Such procedure should result in enriching the high school science course with principles which have large value in the interpretation of life-situations.

The check list was formed by: (1) an analysis of advanced books on light, lighting principles, and optics; (2) by gathering problems in life-situations through the means of a survey of the uses of light, their applications and principles in the home, office, shop, factory, and on the highway; and (3) by compiling the opinions and suggestions of lighting specialists, experts and researchers in the field of light and other allied industries and activities.

One hundred and eighty-two persons representing two groups checked the corresponding number of copies of the check list to indicate whether they had "often," "seldom," or "never" needed to know the information contained in the various items. The first group was composed of science professors and teachers, and other persons engaged in professions which called for specialized knowledge in the field of light. The second group represented a cross-section of the adults engaged in the various occupations in Houston, Texas. The results of this survey were then compiled into tables and the items discussed to point out significant implications of the data. General conclusions based on the evaluation of the data were then drawn.

This study though limited in its scope reveals the needs of understandings in the field of light by the adult population in order to interpret properly their life-situations. The definite findings of this study are listed as follows:

1. The principles in light found to be most useful in the development of functional understandings may be grouped in the following rank order: (1) diffusion, (2) intensity of light, (3) refraction, (4) principles of color, (5) reflection, (6) physiological principles of the eye, (7) dispersion, (8) persistence of vision, (9) visual angle, and (10) properties of light.

2. These principles in light are exten-

sively applied in the efficient and hygienic use of light in the home, shop, office, school, and other centers of human activity.

3. The wise applications of these principles in light are essential in the establishment of proper highway safety measures.

4. The progressive professors of science and specialists in the field of light were found to be dependable and accurate in their estimation of the principles in light needed by the average adult in the daily activities of his life.

It is recommended that in the reconstruction of the science curriculum emphasis be placed upon those principles which have been found to be useful in the interpretation of real-life problems. It is further recommended that the applications used in developing understandings of these principles be taken in a large measure from the situations common to the areas of human activity. The correlation of certain principles in many real-life problems appears to make practicable the correlation of many of the principles from the fields of light, physiology, psychology, and health education.

It is necessary that objective data in a much larger quantity and of a more extensive nature be gathered. The drawing of large generalizations applicable to many and varied situations depends upon a larger number of cases than were possible in this study. Scientific procedure includes the gathering of data in a large number of cases, and of suspending judgment until sufficient data have been considered to either support or refute our hypothesis. The recommendation is made that further research in the analysis of adult needs of understandings taken from all areas of science be undertaken in many localities. A vast amount of data drawn from wider and more diversified sources would furnish the basis for the drawing of more thorough and more dependable generalizations.

The items of the check list used in this study were:

1. Why frosted glass electric light bulbs should be used for lighting instead of clear glass ones.
2. Why electric light bulbs frosted on the inside are better than those frosted on the outside.
3. Why dyes show color when held to the light.
4. Why dyes fade on continual exposure to light.
5. Why books with highly polished paper are difficult to read under bright light.
6. Why rooms for day-time use should get the most sunlight.
7. Where warm or cool-colored wall-paper should be used.
8. Why house numbers should be lighted at night.
9. Why outside home entrances and steps should be lighted at night.
10. Why red is considered proper for Christmas decoration.
11. Why ceilings of light color aid in getting a good lighting effect.
12. Why one needs twice as much light for sewing on dark goods as for sewing on light colored goods.
13. Why electric light should be kept free from dust and dirt.
14. Why two colors matched under daylight often appear different at night.
15. Why one should never work or read by a glaring light.
16. Why the lower parts of walls should be drab or gray.
17. Why floors of dark color do not cause eye discomfort.
18. Why rough walls aid in ridding light of its glare.
19. Why a very bright light used in reading the newspaper does not tire the eyes.
20. Why sewing calls for more light than most other household tasks.
21. Why one should not read in bed and use only the bed-lamp.
22. Why hall lights should be placed high above the eye-level.
23. Why the kitchen stove and tables should have separate lights.
24. Why dressing table lights should be placed forward on the sides of the mirror.
25. How to use the electric eye in checking the lights of the home.
26. Why light should fall on our work, and not just in the eyes.
27. Why light colored open top shades should be used around the lights.
28. Why concealed lamps that shine on the ceiling are the best.
29. Why white paint added to colored paint gives a tint.
30. Why black paint added to colored paint gives a shade.
31. Why colors harmonize just as musical notes do.

32. Why poor quality window glass should not be used for window panes.
33. Why window shades should let some light sift through into the room.
34. Why Venetian blinds are better than ordinary shades for regulating light.
35. Why reading lamps should be placed behind and above the chair.
36. Why polaroid glasses shut out more glare than ordinary ones.
37. Why it is hard to sew on a garment of two different colors.
38. Why green should be used freely in home decorations.
39. Why table tops should not be highly polished.
40. Why baby carriages should be lined with dark materials.
41. Why frosted glass used to encase private rooms must be lighted.
42. Why writing desks and sewing machines should be movable for daylight adjustment.
43. Why lights in children's rooms should be lower than for adults.
44. Why non-glare rear vision mirrors should be used in automobiles.
45. How to use photo-flood lamps in taking pictures at night.
46. Why yellow headlights are better than clear ones in dust or smoke.
47. Why traffic signals should be lighted.
48. What defect in the eye causes some people to be color blind?
49. Why one walking on the highway side at night should wear light colored clothing.
50. Why auto headlights should be adjusted to throw a flat beam.
51. Why the auto headlights should light the right side of the highway.
52. Why the height of the auto headlight beam should be about forty inches.
53. Why auto headlight reflectors should be kept bright and clean.
54. Why well lighted highways are better than bright auto headlights.
55. Why tail lights and small side lights should be used on autos.
56. Why business street lights should be placed higher than residence street lights.
57. Why non-glare lights should be used on highways and streets.
58. Why aviation field wind cones should be lighted.
59. Why the rear vision mirror should stay focussed on the rear highway.
60. Why glaring headlights are sometimes worse than none at all.
61. Why the auto dashboard instruments should have a soft green glow.
62. Why it is not easy to see through a rain covered windshield.
63. Why one cannot see far through fog even with strong lights.
64. Why we get more sunlight in summer than any other season.
65. Why a camera takes a picture.
66. Why dull writing paper is better for number drill than shiny paper.
67. Why dull writing pencils are better than shiny writing pencils.
68. Why it is possible to see oneself in a mirror.
69. How to make pictures of distant scenes by the use of infra-red photography.
70. Why one should look off now and then during continued reading.
71. Why reading by poor lights causes eyestrain.
72. Why strong light shining in the eyes causes temporary blindness.
73. How the compound microscope makes large images of very small objects.
74. How field glasses make close images of distant scenes.
75. Why moving pictures appear to the eye to be moving.
76. Why photo flashlights give light only once.
77. How color pictures are made for the movies.
78. How to focus a camera.
79. Why a folding camera is more difficult to adjust than a box camera.
80. Why one should wear sun glasses on very bright days.
81. Why one should wear goggles in taking ultra-violet ray treatment.
82. What kind of glass to use in letting in the health rays from sunlight.
83. Why many people need bi-focals at the age of forty.
84. Why one should never wear bargain counter spectacles.
85. Why a yellow ball should be used in night games.
86. Why bright footlights are hard on the eyes.
87. Why more light is needed for night tennis than night skating.
88. Why one cannot tell time easily by the image of the clock in the mirror.
89. Why distant track rails seem to come together.
90. Why distant hills seem to have a blue tinge.
91. Why water in an electric fountain falls in a lighted spray.
92. Why lantern slides are used upside down.
93. Why a slanting spoon in a glass of water looks broken.
94. How the sun dial is used in telling time.
95. How the reading glass burns paper in the sun.
96. Why a lake is always deeper than it appears.
97. Why a reading glass makes print look larger.
98. What causes eclipses.
99. What causes the rainbow.
100. Why colored advertisements are better than plain black and white ones.

101. How light is used to record and produce both pictures and sound in the movies.
102. Why indirect lighting causes less glare than semi-direct lighting.
103. How the film for color pictures differs from ordinary films.
104. How color pictures are printed.
105. Why the brightness of a lamp seems to decrease very rapidly, as one moves away from the lamp.
106. Why more light is needed in a drafting room than in a business office.
107. Why as much light is needed in a machine shop as in business office.
108. Why the whole room should be lighted when one reads by a table lamp.
109. Why sodium vapor lamps are very useful in highway lighting.
110. Why a large portion of the wall space in school buildings should be windows.

SCIENTIFIC ATTITUDE AND THE 3 R'S

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Much is said about the place of scientific attitude among laymen in democratic society, and about the role of schools in developing that attitude. Attitudes are sometimes considered more important than mastery of the 3 R's or the other tool-subjects which stop at the fact or skill level of accomplishment. Present considerations of the subject are grouped under four heads: nature of tools, science as a pattern of explanation, scientific attitude and cooperative enterprise, and the schools and the teaching of scientific attitude.

NATURE OF TOOLS

To the typical American "tool-subject" refers to the aspects of formal schooling related to reading, writing, arithmetic, spelling, and perhaps manners, morals and the basic laws of the land. The tool concept, however, is much more comprehensive. Thus the automobile may be a tool enabling one to commute to work, as the ax is a tool in felling a tree; the hypodermic needle may be a tool in medical treatment, as the spoon is in eating soup; or the bridge may be a tool in crossing a river, as the rope ladder is in mountain climbing. Vocal cords and telegraph instruments may both be considered tools of communication, as both the human stomach and the food-preparation laboratory may be tools for carrying on certain digestive processes. Obviously a tool may aid man in primitive tasks which he performed laboriously before devising the tool. If it seems less apparent that a tool may also enable man to perform tasks wholly impossible before devising the tool, reference need only be made to the use of boats in ocean travel or of microscopes in detecting bacteria.

As considered thus far tools are devices which can be seen, felt, or otherwise experienced by the sense organs. In a sense, attitudes may be tools in motivating behavior, and scientific attitude a tool regarding certain patterns of behavior. Psychologists regard thinking as a process of reorganizing experience into new patterns, and regard techniques of analysis, comparison, and evaluation as complex tools used in thinking. Simpler tools may consist of language as labels for meanings, or mechanical instruments for observation or calculation. Among experiences which influence one's thinking are many which are forgotten as separate or individual experiences. Without laboring the point, one may refer to habits and to much emotional conditioning as typically established in this way. Accordingly adults immediately reject suggestions not in harmony with early conditioning, or immediately accept suggestions in harmony with it. The emotional potence of slogans or catch words and phrases illustrates the point; i.e., home, mother and babe, land of liberty, pagan,

murderer, fascist. Hence when a particular case arises which falls in a conditioned category, as murderer, immediate emotional response is typical, rather than reasoned procedure based on facts of the particular case. Thus attitude is an important tool in thinking—a factor determining whether analysis and reasoning will be invoked, and if so the atmosphere under which they will be used.

SCIENCE AS A PATTERN OF EXPLANATION

Native curiosity seems important in man's seeking explanation for things not understood. Of course, additional information, or insight as to different interpretations of existing information, means that explanations once accepted are modified or discarded. In regard to modifying old explanations through added information or insight, the difference between primitive magic and modern science seem largely one of degree. Primitive man with his magic, superstition and animism was offering the best explanations he could for what happened—granting that he commonly framed his explanations in terms of powerful man-like gods, augmentations and glorifications of powerful members of his species. Hence if science is considered a method of arriving at the best explanations of current happenings that available information makes possible, there was considerable scientific thought among prehistoric men—and a great deal of it before the "rise of science" during the past three centuries.

The kind of improvement of explanations suggested in the foregoing paragraph, presumes that invention and discovery are largely by accident—turning to practical use something that results from a happy chance combination of circumstances. One stage of scientific development is thus represented; that of incorporating into thought and practice what new evidence appears. Advancement, however, depends on chance appearance of the new, while man's contribution lies in integrating the new with the old.

A higher stage of scientific development appears when man ceases to depend on chance to impress new evidence upon him, but deliberately searches for such evidence or sets up experimental conditions to produce it. Experimental science therefore not only embodies the practice of basing procedures on all available evidence, but also the practice of deliberately seeking additional evidence to see whether it substantiates prevailing explanations.

Science and magic then are on common ground in that both represent patterns of explanation for happenings. It is only reasonable to expect present-day explanations to be more in accordance with what are now regarded as facts, than are earlier explanations. If the range of information expands during future centuries, it is likely that many present explanations will then seem to leave much out of account, and will be regarded as magic and superstition; i.e., naïve answers to the riddles of nature.

The point regarding similarity between science and magic as pattern of explanation may be carried somewhat farther. Primitive laymen sought answers from the high priests of the oracle; modern laymen, with no less anxiety when near starvation or destruction, rely on the high priests of science. Ceremony was the laboratory technique of the priest of the oracle: precision of ritual in preparing a sacrificial animal for the block was as important, according to the best knowledge of the time, as is care in preparing the modern patient for the operating table, according to modern surgical knowledge, if promising results were to be secured; regularity or prayer and sacrifice were considered to be as important in man's health and prosperity, as regularity of feeding and bathing are now considered to be in the welfare of young infants. Conscientious priests of the oracle and of science thus sketch procedures and make predictions according to the best knowledge of the time. When

predictions come true, it may be a result of chance in some instances, but in most cases it results from an intelligent association of past observation with the problem at hand. The fact that in the case of primitive priests and modern scientists a halo of respect and reverence may appear—known to sociologists as social distance, which may be selfishly exploited by the priesthood of either category, does not argue away the point that the major successes of both priesthoods result from extensive observation and from reflection on experience. Science, however, is based on more accurate and a wider range of observations, and has devised methods of seeking and producing evidence to bear on problems.

SCIENTIFIC ATTITUDE AND COOPERATIVE ENTERPRISE

Attitudes of laymen and scientists, either toward incorporating the new that accidentally appears or toward definitely seeking or attempting to produce something new, are obviously important concerning the range of things for which explanations are attempted, as well as the rate of improvement in explanations offered. Attitude may be especially important when the stream of new information becomes so great that generalists cannot keep up with it, and specialists develop to perform the function in particular areas. Clearly it is here assumed that information is not withheld from generalists because of superstitions, taboos regarding forbidden knowledge, or modern equivalents in selfishness, but rather that the time and energy at the disposal of one person prevent his mastery of all fields. Specialization means that vested interests develop in the specialties. Attitude of the scientist will determine whether the accumulated information and interest in the special field will be used for the further development of knowledge and of public well-being, or for the selfish advantage of the scientist. As illustrative of the role of attitude and vested interest one might note the antagonism of Paris medics to Pasteur's bacterial interpretation of disease, or the antagonism of certain present-day medical organizations to publicly sponsored efforts for extending medical service to low-income groups, or perhaps to the witch hunts of colonial New England.

Overcoming vested-interest exploitation by particular specialized groups which may not be selfishly motivated, however, would be inadequate from the standpoint of the scientific attitude essential to a society of extending economic interdependence and hence of increasing cooperative responsibility for further social development. The point in brief is that society in general cannot advance beyond a certain level through improvement of one specialty, when other specialties are neglected, no more than a child will grow normally who has plenty of protein in his diet but no lime for bone building. Obviously coordination of specialties is the point, which means cooperation of planning and activity among different agencies of specialization. Cooperation in this sense demands a scientific attitude that goes beyond the two stages already mentioned—incorporating new evidence, and deliberately seeking evidence. It means that the attitude of deliberate search and experimentation must be extended to different fields, not in their isolation as it has largely been in the past, but in their possible interrelationships. Hence experimental and research undertakings become more comprehensive in scope, and are planned by groups representing different specialties, as seems increasingly the case in this country. When scientists sense responsibility for the influence of their discoveries on developments in related fields, or in broader areas of social relationship and regulation, lofty disregard of scientists for the moral consequences of their work will disappear. That is to say that some sense of moral responsibility for the predictable social consequences of scientific discovery will become a part of scientific attitude. This aspect of the evolution of scientific attitude

seems to be emerging, but is not yet generally manifested.

SCHOOLS AND THE TEACHING OF SCIENTIFIC ATTITUDE

If one admits the importance in an industrial society of lay development of a scientific attitude, question arises regarding machinery available for the job. Attention thus focuses on the school. Beginnings in this development at kindergarten and primary levels may be quite simple—so simple that many persons see nothing scientific about them. When the child at home or in the kindergarten learns to put his toys away when through with them, because if put away they are less likely to be trampled underfoot and broken and because they can be found next time he wants them, he is receiving experience in cause and effect relationships. His experience with causal situations is expanded when he sees that other things, besides putting away toys after play, may be related to toy breakage; i.e., how he handled them in play, which playmates use them, *et cetera*. With a complex electrical or mechanical toy there may be several reasons why it ceases to work. Herein lies an opportunity of inducing the child to look for this or that factor, and for parent or teacher to share in the search. Experimental attitude develops when one hypothesis is tried, and upon failure is discarded for another. Within limits the same applies to substituting one toy for another.

A sense of social or moral responsibility in the use of one's information or material possessions may develop through toy and play experience. Thus the child should learn that he must not use his popgun or tricycle in the antisocial way that some adults use a radio—to the annoyance of the whole community. Thus respect emerges for the rights of others, and an understanding of the necessity for cooperation when several persons live in one household or in one closely knit community.

Other illustrations describing easily graduated steps between the kindergarten-primary level and secondary of higher education could be included if space permitted. At the secondary and higher levels, however, much toward the development of scientific attitude can be done vicariously—through oral and written accounts reflecting the scientific attitude, or lack of it, in the lives of particular individuals, or in certain technological and social developments. First-hand experience, however, is also needed. Problem study in the classroom and in the community has been emphasized as one means of developing an understanding of causal relationships and an attitude of search for various ramifications of problems and of factors bearing on them. In laboratory aspects of natural and biological science this implies the kind of field trips which urge students to be alert to problem situations and to information bearing on them, rather than for them to be told in detail what to see on trips or to be cudgeled to follow at school a laboratory manual with the slavish lack of imagination characteristic of heathen rain-making ritual. In the social sciences it likewise implies contact with prevailing social conditions and problems—direct visits to community institutions, augmented by films, and supplemented through statistical and other reports. The entire secondary school curriculum needs more emphasis on methods of securing facts and arriving at conclusions, rather than on particular sets of facts or conclusions that prevail at the moment. Thus emphasis can be placed on experimentation *as a means of solving problems,* and the attitude of experimentation rather than the concensus of the oracle or council directed toward the field of law and social problems, as well as toward natural science and technology. Following the results of invention and technological change into the community and nation should then lead youth to see what is meant by the social and moral implications

of discovery and invention, and to see why the scientist or inventor should be brought to feel some degree of moral responsibility for the consequences of his work. Knowledge of the social and moral consequences of one's acts is emphasized in the courts in holding one accountable for what he does; as it is emphasized in training citizens for democratic society, in developing the capacity to foresee and predict the consequences of individual and collective acts. When scientists and inventors are in a position to influence social trends much more extensively than is the average citizen, it seems that a part of their training and experience should likewise develop a sense of social and moral responsibility for the consequences of what they do.

A sense of moral responsibility, as here characterized, does not mean that all scientific and creative thought must be channeled into the narrow grooves of some existing totalitarianism, but it does suggest that anarchy in scientific and similar creative fields is not the only alternative to such totalitarianism. In a society with great and increasing industrial and economic interdependence, the school should be responsible for doing what it can toward developing in laymen and specialists a scientific attitude regarding the methods of technological and social change, including a sense of individual and collective responsibility for the consequences of such change. The development of such an attitude among laymen in this country, may be more important for the future of democratic institutions, than emphasis on the 3 R's—the tool subjects in the conventional sense.

THE CHEMISTRY DEMONSTRATION AS ENTERTAINMENT

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Chemistry teachers, everywhere, are asked from time to time to give a ten minute program of interesting demonstrations. The nature of the audience may vary from an all-student group to an all-adult group, or a combination of old and young. Yet the character of the demonstration should meet a few simple but obvious requirements, to wit:

1. It should be free of any serious fire hazard and dangerous explosiveness.
2. It should permit of being carried out on a sufficiently large scale to be visible to everyone in the auditorium.
3. It should be as spectacular as possible.
4. It should not rely too much upon the knowledge of the audience but appeal rather to the senses and the emotions.
5. It should be presented as humorously as will comport with the necessary dignity of teachers.
6. A demonstration is most striking when it is "dressed up" or "built-up" in a manner to make the audience say—"My, isn't that wonderful? I wonder how it's done."
7. It should be easy to perform.
8. It should be "proof against failure."
9. It should not produce noxious gases in sufficient quantities to distress the audience.

Criteria Nos. 1, 2, 3, 7, 8, and 9 need no further comment. The thought of No. 4 is that a demonstration which obliges the operator to stop and explain what has happened loses its force. Concerning suggestion No. 5, it is scarcely necessary to remark that one or more good laughs add zest to any program and in a science-demonstration serve the additional purpose of pointing out that chemistry can be "lots of fun." The thought of suggestion No. 6 is that, if the operator has some apparent reason for his act, the performance takes on a high degree of interest and endows the simplest chemical reaction with

an air of mystery and intrigue. One can so dress up the most familiar reactions as to make persons who know the underlying chemistry unable, momentarily, to give the correct explanation. By such an approach the chemistry demonstration, far from boring those who have studied this science, will entertain adults and serve as a review for students, at the same time arousing an interest in this discipline on the part of those who have not yet studied it.

With these thoughts in mind, the following set of demonstrations was prepared and given at our school one evening, recently, during a "Parent-Teachers" meeting. The time allotted was about twelve minutes. It was deemed appropriate to the character of the occasion to have a student perform the demonstrations, and for this purpose a very enthusiastic senior * was selected and trained. The choice of both operator and demonstrations proved happy and the audience seemed appreciative and entertained. No claim of novelty is made for any of these chemical reactions. On the contrary, as has already been emphasized, part of the plan was to start with the commonplace and to make it entertaining without recourse to complexity or rarity.

Cute Comical Chemical Capers

(The stage is in complete readiness, with microphones, if available, arranged properly at either or both ends of a long table, or several short tables placed end to end. On this table, beginning at one end, is placed all the apparatus necessary for demonstration No. 1, and, progressing to the other end of the table, is placed all apparatus in the order in which it will be used as the demonstration moves along. The table should be as far front on the stage as possible and all apparatus should be placed as far front upon the table as possible. If the school is equipped with spotlights, the operators of these should be in readiness.)

1.

Demonstrator appears from behind curtain in darkened auditorium with a candle in his hand. (Spotlights go on.) Lights candle and says:

* Morton Surkin, now a student at one of our universities.

"My, but I'm cold and hungry.—I think I'll raid the ice-chest."

Walks to one side of stage and peers into imaginary ice-chest, passing lighted candle back and forth along imaginary shelves.

"Hm—there isn't a thing to eat—all I can see is some cod-liver oil and grandma's medicine. And I'm hungry enough to eat—"

Pauses—snaps his fingers and says:

"That's an idea! Why not?"

Eats candle, with gusto and says:

"Yum—yum! Delish—ous!"

2.

Stands at left of table and says:

"Speaking of candles. I'm going to put this candle flame out by pouring nothing upon it."

Lights a candle. Holds bottle of "nothing" up, so audience can see that bottle is "empty". Pours from bottle upon candle-flame, which is immediately extinguished. Says:

"Now I'm going to relight the candle by pouring nothing upon it again."

Holds bottle of "nothing" up for audience to see, then pours it upon candle, which immediately relights. Stands in back of table and says:

3.

"Now that I've looked after my hunger, let's see if I can warm up a bit."

(Spotlights go out.) Pours a liquid into a pan and throws a lighted match into it. Flames arise. Puts his hands into the pan and brings out some of the flaming material, which he pulls apart at arm's length. Puts flames back into the pan and bathes his hands in flames. Then puts asbestos board over latter to stop combustion.

4.

(Lights in auditorium go on.) He says:

"That's much better. Now for something to drink, to wash the candle down. Um—"

Stands behind table, to the far front of which are a transparent glass pitcher and four 8-ounce drinking tumblers. Says:

"Well, I see I have a very wide choice here."

Raises pitcher for audience to see that it contains "water".

"Shall I have——um——wine?"

Pours from pitcher into first glass. Holds up "wine" for audience to see. Turns up his nose and says:

"No, I believe I'd rather have orangeade."

Pours again and holds it up.

"Shucks, now that I've made orangeade I wish it were milk instead. Well, let's see, maybe—"

Pours and then holds up "milk".

"No, I guess it's soda water I want, after all."

Pours soda, holds it up, turns up his nose at that, too.

5.

(Lights in auditorium suddenly go out.) He exclaims, greatly surprised:

"Who put the lights out?"

Walks behind table to right end and from underneath it quietly removes a soap box (painted black so as to be unnoticeable until now). Sets box out to right of table about two feet in back of footlights. He strikes a match and pretends to be groping around in the dark, trying to find a light, but actually lights the Pharaoh's serpent, with his back to audience, so as to conceal the entire act, and then steps back of box. Spotlight is then thrown "suddenly" upon box and he sees the growing serpent. Jumps back in horror, and says, after a long pause:

"Goodness—I'm seeing things!"

Raises his arm as though making a resolution and says:

"I promise never to eat candles again!"

6.

(Spotlights on from now to end of performance.) Stands behind middle of table and says:

"Guess I'd better take some hot water to get over this candle indigestion and nightmare."

Taps a teaspoon on the table to show that it is metal and flourishes it innocently to let audience see it. Puts spoon into hot water in a cup held shoulder-high. Spoon disappears. Says:

"Great Caesar and little apples!"

7.

Says:

"Well, I can't go to bed feeling this way. I'll have to make up some other medicine."

Measures out two "medicines", each in a different graduated cylinder. Pours each "medicine" into a different cup in such a way as to allow audience to see he really has poured them, then pours from one cup into another. Tells audience he certainly hates medicine and wishes it would disappear just as the spoon did. Looks into the cup. Stares in bewilderment. Tries to pour medicine into other cup, in view of audience, but it seems to have disappeared. Says:

"What on Earth! Well—I got my wish, anyway."

8.

Stands toward right end of table, behind two glass jars, one on top of the other. Says:

"Wow! That candle's filled me full of ghost-smoke. See if I can blow the ghost-smoke into these empty bottles."

Permits audience to note that they are empty, by pausing. Makes a few magic passes and utters some abracadabras. Blows upon bottles. Smoke appears inside of them.

9.

Stands a little further to right, behind a large jar of "beet soup". Says:

"By the way. Mother asked me to strain this beet soup before going to bed. Guess I'd better do at least one useful thing today."

Pours "beet soup" into a second jar which has thin gauze stretched across it. As liquid enters second jar, it is colorless. Says, resignedly:

"Can't I do anything right?"

10.

Hears strains of "Columbia, the Gem of the Ocean." Says:

"Hurrah for the red, white and blue!"

Stands at extreme right end of table and pours three liquids into a large glass cylinder, one after the other. Brilliant layers of red, white, and blue appear.

Curtain

HOW IT IS DONE

1. The candle is prepared by carving a piece of turnip into the correct shape and inserting a sliver of almond kernel for a wick, which will burn brightly and easily, if it has been previously charred, by kindling, before the demonstration starts. A banana is probably as suitable as the turnip. As the candle is brought to the mouth, the demonstrator should exhale air so as to extinguish the flame, undetected by the audience. If a turnip is used, the "candle" should be thin, otherwise the operator has to chew too long.

2. The first bottle (eight ounce, wide mouth), contains carbon dioxide. It is well to force a thin piece of wooden splint into the candle along the wick so that both splint and wick protrude about the same distance above the wax. This insures retention of a good spark when the second bottle, which contains oxygen, is emptied over the wick. Care should be taken to wipe drops of water from the mouths of bottles, if the gases were collected by wet displacement, as one drop of water poured upon the candlewick will cause failure.

3. The agate pan contains asbestos pulp. The liquid ("cold fire mixture") is 58 per cent carbon disulphide and 42 per cent carbon tetrachloride. About twenty-five (25) cubic centimeters are used. The pan should be as shallow as possible, so that flames are easily visible, and it is wise to have a large sheet of asbestos board or paper under it, although the demonstration is very safe. The demonstrator should not stand where his lungs can fill too rapidly with the products of combustion. He should not let the liquid burn itself out, but, immediately after the demonstration, should stop combustion by covering pan with an asbestos board.

4. The clear glass pitcher contains 100 c.c. of a saturated solution of sodium carbonate (about 20 grams of washing soda) plus one quart of water. The first glass contains a pinch of finely ground potassium permanganate, the exact quantity to be determined by the lighting conditions of the auditorium. The second glass contains a pinch of any water-soluble orange colored dye and one c.c. of saturated barium chloride solution near each other, but not mixed. This latter produces sufficient barium carbonate to give the turbid appearance of orangeade. The third glass contains 30 c.c. of saturated solution (about 18 grams) of calcium chloride and the fourth glass 30 c.c. of saturated solution (about 25 grams) of tartaric acid.

5. Pharaoh's serpent may be prepared as follows: Dissolve about 30 grams of mercuric nitrate in about 500 c.c. of water and add a little nitric acid to clear the solution, if necessary. Now add a few drops of ferric chloride solution and then, gradually, sufficient potassium sulphocyanate solution to obtain a permanent pink color, (about 25 grams of the sulphocyanate dissolved in about 100 c.c. of water), stirring after each addition. Allow to settle, wash by decantation and allow to air-dry for several days on filter paper, or dry carefully and gently in an "oven." When dry, take as much as will fill a cone produced by folding a piece of 9 cm. filter paper as though ready for filtration, and moisten the powder with sufficient alcohol to make it plastic. Now transfer the mass to the filter-paper cone and allow to dry. Handle gently while removing filter paper from dried mass. Such a cone will produce a serpent 2 or 3 feet long and 2 or more inches thick. When using, place on asbestos card in center of box, which should be large, so that the serpent formed does not crawl to end of box and break off in the fall. Tilting the cone forward a trifle by supporting it on a wedge may encourage the ash to go forward on the box and thus be better seen by the audience.

6. The spoon is made of Wood's metal (bismuth 50 per cent, lead 25 per cent, tin 12.5 per cent, cadmium 12.5 per cent). A spoon with flat bowl, but creating the proper illusion, may be cut from a sheet of the metal. Or an ordinary kitchen teaspoon may be cut into several parts at strategic places and soldered together with Wood's metal. Finally a very realistic spoon may be prepared by casting.* If no electric heater is available for stage use, the "hot water" can be prepared by heating a saturated solution of sodium chloride, until needed, by means of an alcohol lamp.

7. The "medicines" consist of a) 4 c.c. of saturated aqueous calcium acetate solution (about 43 grams per 100 c.c.) and b) 20 c.c. of 95 per cent alcohol. Owing to the variability of the strengths of both solutions, the best proportion of each solution should be ascertained by experiment. If absolute alcohol is available, 14 c.c. of it and 4 c.c. of calcium acetate give good results. Some chemists suggest the proportions of 5 c.c. of calcium acetate solu-

*A fully detailed method for preparing such a spoon will appear in an article "Casting Fusible Metals for Teaching Physical Change" in a forthcoming issue of "School Science and Mathematics."

tion to 45 c.c. of alcohol. It is good practice to pour the mixture from one vessel to the other, while waiting for it to gel. Here the demonstrator has an opportunity to introduce some humor.

8. Two wide-mouth bottles each of one liter capacity are suitable for this demonstration. One has enough hydrochloric acid poured into it to completely moisten the inside, and the other is similarly treated with ammonium hydroxide. Each is covered with a glass plate (circular in shape, if available) and then both are supported, mouth to mouth, by ring stand and clamps or rings, as otherwise the top bottle will be constantly in danger of falling. Neither liquid should be used in quantity sufficient to form a pool of liquid in the bottle. Either the mouths of the bottles or the glass plates should be heavily greased with vaseline, to prevent constant fuming. The bottles should be prepared immediately before use. The demonstrator should remove the plates between the bottles in such a manner as not to let the audience notice this act. A hand placed in front of the plates during the abracadabras accomplishes this nicely.

9. Two wide-mouth bottles, of one or two liters capacity each, will serve well. One contains about 15 grams of sodium sulphite dissolved in about 50 c.c. of water and has a piece of gauze stretched across it, to create the illusion of "straining." The other bottle is full of a solution containing just enough potassium permanganate per bottle full of water to give the "beet" color, to which about 10 c.c. of concentrated sulphuric acid have been added.

10. A glass cylinder of about 12 inches in height and 2 inches in diameter (such as is used for specific gravity demonstrations) may be employed. The blue liquid is made by grinding a few grams of litmus cubes to a fine powder and suspending the latter in about 150 c.c. of carbon tetrachloride. The white is made by mixing 75 c.c. of water containing 20 grams of barium chloride and 75 c.c. of water containing 15 grams of sodium carbonate. The red is prepared by suspending a few grams of carmine in about 150 c.c. of a light immiscible liquid such as amyl alcohol. These suspensions should be prepared immediately before the show, from materials previously made completely ready and the suspensions should be agitated frequently, if necessary. This is a spectacular demonstration and is worth a little practice, before hand, by the demonstrator. A satisfactory way is to proceed as follows: Two thistle-tubes or funnels are selected and the stem of one of these is bent at a right angle, about 1½ inches from the bottom. The demonstrator delivers the carbon-tetrachloride suspension (blue) to the bottom of the cylinder without wetting its upper portions, by means of the straight thistle-tube. Now he places the second empty container and the thistle-tube down and picks up the red suspension and the bent tube, through which he delivers this liquid against the side of the cylinder, to break the force of the former and thus prevent its penetration to the carbon-tetrachloride layer. A surprising degree of nonchalance can and should be developed by the demonstrator, who, with previous practice, can easily learn to make the demonstration come off well. Even though the liquids are poured rapidly and some of the white seems momentarily to penetrate into the blue, or some of the red into the white, the layers soon separate satisfactorily. The containers of the liquids should be opaque. A source of strong illumination in back of the cylinder, after the three layers have been poured, would be useful in heightening the effect.

A few final hints may be useful. It is good practice to have a fire extinguisher or a supply of carbon tetrachloride handy. Extra supplies of materials should also be on hand where easily available—for ex-

ample another Pharaoh's serpent (on black box), oxygen and carbon dioxide tanks, water, and a waste jar, where convenient. The entire performance should be well rehearsed under the same conditions which will prevail on the day of the demonstration, so as to forestall any failures. A spotlight, though not imperative, can be used to great advantage on all the demonstrations, with the exception of No. 4.

TEACHING THE BEGINNING OF NEW LIFE

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WE FOLLOWED THE TRADITIONAL SCIENCE SEQUENCE

Placing biology in the tenth grade at the Atlanta University Laboratory high school was purely according to the traditional high school science sequence. The needs or interests of 14 to 16-year-old children were not a part of the consideration nor was the question of the appropriateness of the curriculum material to the achievement level of the boys and girls. These factors were not even considered except as they may have been a part of the plan of those "curriculum experts" originally responsible for the science sequence. Such matters as course sequence were so fixed by long tradition that they were to us a part of the unquestioned plan for the American high school.

WE QUESTIONED OUR "BOOK-STORE" CURRICULUM

Along with its place in the science sequence, the curriculum of biology was also an established fact. Our responsibility seemed merely to be the choosing of the "proper" textbook and covering it as adequately as possible.

With the introduction into our school some eight years ago of the "Morrison" learning units of the mastery type there began to develop very gradually, but very persistently, a critical, questioning attitude on our part toward both the materials and the techniques which had been formerly taken for granted in the biology course.

As long as a basic text was used the interest of the pupils was largely in acquiring and memorizing facts as they were presented more or less chapter by chapter in the chosen textbook, and periodic mastery tests were used as a measure of progress and success. Some additional reading or laboratory activity was frequently motivated by the periodic report cards then in use in the school, which promised higher marks for the work beyond that "required" by the course, and always a few interested pupils could be encouraged to use the "related" materials in the school library. Articles in magazines and newspapers were frequently brought to the teacher by alert pupils.

At first the "Morrison" units were based upon the textbook material, but with continued use of work-sheets containing more and more material from selected references, there was a gradual increase in the use of references to the growing number of interesting books in the library and to other textbooks besides the basic text which each pupil was required to own. After two or three years of this sort of modification of the teaching materials the basic text had

lost its importance as the main source of information to such a degree that the teacher conceived the idea of attempting to teach the course without a basic textbook.

The school library collection by this time was fairly adequate and the librarian agreed to cooperate by securing a number of additional references. From the pupils came the suggestion of pooling funds so as to increase the supply of the materials which were beginning to accumulate in the classroom library. So with some trepidation on our part the course was begun one year without a basic text.

A LITTLE FREEDOM LED TO A MORE DEMOCRATIC CURRICULUM

The new freedom seemed to suggest taking more liberties with the course and occasionally pupils individually or in groups came to the teacher to propose "units" or questions that interested them. Boy scouts wanted to know more about snakes; black-widow spider incidents suggested more intensive study of spiders and insects; personal experiences and current articles aroused interests that brought additional requests until it began to be quite apparent both to the teacher and to the classes that units of study could with profit be both suggested and planned with considerable participation by the pupils.

MORE DEMOCRACY BROUGHT "TROUBLES"

Several difficulties from the teacher's point-of-view began to appear. Along with a very evident increase in pupil interest and generally improved study habits and study skills, there appeared a danger of having so many individual and group interests being pursued at the same time that the teacher had difficulty in giving to some pupils the necessary amount of help without, at the same time, neglecting others who were slow by reason of poor reading and writing skills and other learning handicaps. But even that early stumbling effort at individualizing the classroom procedure paid so much in unexpected dividends of greater interest and increased purpose for both pupils and teacher that it was never a question of solving the problems by abandoning the method because we did not know how to use it well. Fortunately other teachers on the staff were developing similar techniques in their areas and it is enough to say here that in the end our troubles began to disappear and together we learned to give enough individual attention to those pupils who needed it most and gradually to withdraw help from those who could with profit make progress without so much of it.

In the same way, as the effort increased to have the course answer more of the problems which the pupils considered important to them, pupil participation in the choice and planning of the units increased to the extent that finally the entire course was planned with their help, and subjects began to be studied which either were not broadly treated or were touched only slightly or not at all in traditional high school biology courses built on textbooks.

WE DEVELOP NEW TECHNIQUES

The techniques which finally evolved were somewhat as follows. The course was introduced with an exploratory period long enough for the boys and girls to discover what sorts of questions a biology course should answer for them. Then with as full knowledge as possible of their relative value, the class would choose and arrange in tentative order a list of units that would, during the course of the year, allow them to study as many as possible of the biology interests that seemed most pertinent to them.

As soon as this procedure was begun it became evident that pupils were much more interested in learning about themselves than they were in devoting time and effort to many of the subjects usually treated in high school biology textbooks. The course became immediately much more social in its content. Interest seemed to grow out of very definite feelings of per-

sonal needs and an intellectual curiosity to know.

THE UNIT ON THE BEGINNING OF NEW LIFE IS UNDERTAKEN

One of the first questions that pupils wanted answered was how does a new life begin. Their original interest here was, how does it begin in man. High school textbooks, even the best of them, did not contain sufficient information to satisfy their curiosity. So, at this point new problems for the teacher began to appear.

In our experience in the Laboratory School there have been three distinct problems to be faced and for which we have attempted to find what seemed to be the best solutions.

First, what would be the attitude of patrons if we encouraged the pupils to find the answers to all their questions about reproduction in man? On controversial subjects teachers feel secure in presenting the material between the covers of textbooks. The adoption of the texbook has given approval to whatever it contains. But when classes begin to build their own curriculums and select their own curriculum material the question of what may and what may not be included in certain subject areas takes on new importance.

WE DECIDED TO DO OUR OWN PIONEERING

Three or four years ago the articles written by pioneering teachers in the professional magazines on the subject of teaching reproduction in the high school led one to feel that it was highly important for the school to secure the consent of the parents before material on this subject was presented. We considered this and came to the conclusion that any effort to secure this consent would so exaggerate its importance and would cause such discussion in the home that neither the pupils nor the teacher could begin the study in a normal, frank, broadminded atmosphere.

After very careful and critical consideration by the teacher and the principal, and to some extent by the staff, it was finally decided that we would risk the chance that the study of this material would be so valuable to the pupils that parents would both understand and approve the innovation.

The second problem for the teacher was, could the materials be handled in a class with boys and girls working together. We thought that they could. Our experience had been that boys and girls study, without the least bit of embarrassment, about reproduction in other animals; they must live, work, and play together in life and would it not be possible that they might accomplish this living together more congenially if they knew each other better? Here again our decision against segregation was contrary to the advice given in the professional literature. On the other hand, the professional literature dealt usually with "sex education" as a course instead of placing it along with the other normal life functions of plants and animals. So for three years the tenth grade boys and girls have with careful guiding done their studying together instead of in segregated groups from which there was the possibility that they would eventually compare notes without classroom supervision.

The third problem centered around the reading material. The material on the subject in the textbooks is very limited and does not give enough information to satisfy the pupils. Recently there have been some excellent books written especially for adolescents. Some of them range in reading difficulty as low as the sixth grade. Among these are: "Biography of the Unborn" by Margaret Gilbert, "Growing Up" by Schweinitz, "Being Born" by Strain, and "Life and Growth" by Keliher.

After the teacher with the help of the principal had arrived at some conclusions on these problems the class was allowed to begin work on the unit and for the past three years biology classes have developed a unit around the general subject of the beginning of new life.

The approach to the unit has been no problem at all because pupils in successive classes have already had questions rather definitely in their minds and each class has rather early in the year presented questions that have led to the selection of the unit.

Each year the questions have been more extensive and interest in the unit seems to be increasing. At least, it is more frankly expressed. The work on the unit by the 1939–40 class is described in some detail in the remainder of this discussion.

The main problems were to plan the unit so it would include all of their questions and to outline the procedures to be used throughout the work on the unit.

By consensus of opinion the class decided from their discussion that they wanted to find out how life begins. The next step was to plan the work on the unit. This was done by the class working together with the teacher. Different pupils presented the questions they wanted answered. These were evaluated as to their worthwhileness and whether or not they could be answered by the materials and facilities at hand, and their practical value to the group. After the general outline of the unit was completed, the next step was to plan the procedure. The class this year included both plants and animals in their study. They decided to begin with the simplest animals and to work up through the animal kingdom finding the method or methods of reproduction. They proposed to work on plants in the same way. The class divided itself into groups according to their interests. The greater part of the class worked on reproduction in man. There were two groups working on plants, one with flowering plants and the other with the non-flowering group. The fourth group worked on animals beginning with the simplest ones and working up to the mammal group.

As soon as the groups were formed the work phase of the unit began. At first the pupils were busy selecting their books and planning individual procedures. The teacher was very busy advising and helping pupils to select books at their own reading level. The spirit and atmosphere of the class has formerly depended on this selection being made rather successfully. "Being Born" and "Growing Up" were used as lower level reading material in the group working on human reproduction. "Science and Life" was the lower level book for the group working on animals and "Science and Life" and "First Study of Botany" for the group working on plants.

During this work period they made lists of new words, many diagrams and drawings and dissections, took careful notes, discussed their problems with each other and with the teacher, brought in articles from newspapers and magazines, and finally, they wrote up their problems in complete form to be filed in their individual folders.

Many discussions were necessary for the group working on reproduction in man. Some for clarifying the vocabulary, others for interpreting reading material, but probably the most interesting and most valuable were the discussion periods in which they were convinced by their study that much of the popular type of information they already had was not accurate. This called for careful generalizing and evaluating.

The class dissected male and female foetal pigs in order to study the reproductive organs in mammals. They studied the organs in a bird from a chicken that had been previously dissected and preserved. They had at hand also the fish, the frog, the clam, the crayfish, the grasshopper and the earth worm. The group working on plants used snapdragons from the green house, pine cones, sori from ferns, preserved moss plants, bread mold, a mushroom from one of the flower pots and algae from the aquarium.

Two members of the group working on animals became especially interested in birds. They incubated some eggs, using for this an incubator that had been built

by one of the pupils in the first class to study reproduction in this way. Heat for the incubator was supplied by electricity regulated by a thermostat from an aquarium. They opened the eggs at various stages of incubation to show the progress made during a definite period of time. Their reading was done from "General Biology" by Wheat and Fitzpatrick and from a "Cornell Leaflet" by Lawrence Palmer, (Teachers Number, September, 1939).

A rather wide selection of textbooks has been accumulated in the last few years. The pupils who have no reading difficulties used these books largely for their material about the plants and animals with the exceptions mentioned previously.

As the various groups worked on their problems they found that the gestation period in mammals varied. This brought in a new problem that was not in the original outline. A few pupils took on this extra problem. They were able to find their information in "Problems in Biology" by Beauchamp, Pieper and Frank.

After the majority of the pupils had completed their study, the class assembled for discussion periods during which they shared their information. Different pupils had charge of the discussions and the teacher became only another member of the discussion group. This period was usually very interesting. Each pupil was made to feel himself an important part of the group, free to make his own contribution. Discussions were usually free from fault finding and unpleasant criticism. Necessary criticisms were made privately and quietly so as not to disturb the democratic feeling of the group.

During the discussion phase of the unit many questions were asked which could not be answered by members of the class. These questions were recorded and were later divided by the class into groups according to the fields in which they would appear.

After considerable discussion the question seemed to fall generally into three groups to be answered by a physician, a psychologist and a biologist.

Some idea of the types of questions raised can be gained from the following list:

1. What causes hermaphrodites?
2. Is there more strain on the mother in the case of multiple birth?
3. Does the practice of birth control do anything harmful to the health of the man or the woman?
4. Does the age of the parents have any effect on the child?
5. Is the mother's life in danger during the process of giving birth to the child?
6. Do doctors think abortions will ever be legal?
7. Do mothers act normal during the period of pregnancy?
8. Why are children born deformed?
9. What are some of the causes of miscarriages?
10. What are some of the things that cause the high death rate among infants?
11. Do nervous shocks experienced by the pregnant mother cause malformations of the child?

During the progress of the unit two things were evident. One that the pupils were very serious in their desire to learn about the process of reproduction, and the other that they had a great deal of incorrect information. Since a study of this topic would continue after the class had finished its discussion it was thought advisable to invite some mothers in to listen to the discussion that was to be held with the physician. This idea was presented to the class and they chose three mothers from the Parent-Teachers Association. After the questions were divided the class concluded that they did not have enough questions for either the psychologist or the biologist at the time, so these groups of questions were saved so that they could be increased from later units. Later the psychologist spent two periods with the class after they had studied a unit covering the nervous system and mental hygiene.

The particular physician whom we would invite was decided by a class vote and his discussion centered around the questions which were divided rather roughly under

three heads—birth control, malformation and care of the mother and the developing child. Three different pupils, each one taking a topic read the questions for the physician.

The reaction of the parents, probably, can best be discovered from statements made by them:

> "If these boys and girls get into trouble, they will do it with open eyes. We learned by experience. They will be much better prepared."
>
> "That was a fine thing and they were so serious about it."
>
> "Boys and girls need this information because they see so much in the movies."
>
> "This helped me a great deal because my boy was asking so many questions and I will know better now how to help him."

NEW TEACHING METHODS CALL FOR NEW TYPES OF EVALUATION

The next step was to discover to what extent we had achieved some of the purposes which the teacher and the class had in mind in undertaking the unit.

A test on the application-of-principles was devised by the teacher and administered to give both pupils and teacher an idea as to how much real meaning had been taken on by some of the important principles studied in the unit. A vocabulary test was also administered. This was a matching test composed of a master list of words made by the pupils as they worked through the unit. The results on both tests were gratifying in that they showed considerable progress both in understanding the principles and in acquiring new words.

One of the boys who realized that he had a reading handicap, had made an especial effort to accumulate a large vocabulary and had made a very long word list, incidentally the longest in class. He was particularly pleased to discover that he really knew just about all of his new words. Many of his words were, of course, not new to many others in the class and, naturally, many of the more advanced pupils had shorter lists of new words.

Written tests were not used to evaluate the other objectives set by either the teacher or the class. Records of observations of certain behavior of the pupils were made by the teacher as the unit proceeded. These included certain remarks made during conferences and discussions and records of other behavior that might supply some clues as to the changing attitudes and changing behavior of individuals. These included evidence of ability to work or not to work with other pupils; evidence of increasing purposefulness of attack upon a problem; growing interest in reading; increased ability and willingness to work without so much help; ability to find material; etc.

Opportunity was also given the pupils to make some definite written statements concerning their progress in the course. These included many statements that revealed a decided appreciation of the unit. From one boy came this rather striking statement:

> Through my study of biology I have learned the reproduction of man to be a beautiful thing, yet some men and women are destroying the beauty of it in many ways. I have learned many things that will be helpful to me in the future. And above all I have learned what a beautiful thing reproduction can be—a man and woman falling in love, marrying, making a home, and bringing up a fine bunch of kids. And I see how wonderfully well God had worked this thing out and little man knows about this—there is so much to be learned.

The scope of the unit enlarged as the class proceeded with their study of it. During the work on the outline for the unit the teacher had proposed that some study of heredity and of social hygiene be included but this was rather vigorously opposed by the majority of the pupils and the idea was abandoned. Subsequent work on the unit, however, made it quite generally clear to the group that before they had a very complete picture they would surely need to know something about heredity, the nervous system, and social hygiene. In fact many of the questions reserved for the discussion with the biologist had touched on the subject of heredity. So the next problem was waiting for us.

SOME DATA PERTINENT TO TEXTBOOKS OF GENERAL SCIENCE

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The textbook business in the United States is tremendous. The American teacher apparently believes in using textbooks extensively in his work. Just how big the textbook business is may be conceived by a report made public through the United States Office of Education in 1928. The publishers of textbooks reported a total net sale amounting to $49,097,466. For secondary school purposes there were 18,683,290 books sold for $16,288,422 net. To this amount one-fourth to one-third should be added to cover retail cost.[1] But the average net cost of a high-school textbook was only 87.2 cents.

An educator, speaking before the National Education Association Department of Superintendence, endeavored to define a present-day textbook. He did it quite adequately when he said,

> By *textbook* I mean a book designed for class use, carefully prepared by experts in the field and equipped with the usual teaching devices, such as pictures, maps, charts, tables, questions, texts, and a complete teacher's manual stating objectives, methods, and techniques, and giving every possible aid that might be of service even to the most inexperienced teachers, including answers to all questions and problems in the textbook.[2]

THE DEVELOPMENT AND IMPORTANCE OF TEXTBOOKS FOR SECONDARY SCHOOLS

The textbook is an old instrument in learning and teaching processes. The earliest recorded use of it dates back to the time of Homer. Bacon [3] says, "The textbook is the heir of all the ages. Homer wrote the first one." For general practical purposes textbooks were unknown until many years after Gutenberg introduced the movable type near the middle of the fifteenth century.

Our textbooks have been improved greatly even in the past fifty years. Rugg characterizes the secondary-school curriculum as being morphological previous to 1900. In speaking of the textbook writers he says,

> Its designers were interested in classification, in naming parts and describing forms, rather than in developing an understanding of function and functioning. . . . The acme of the morphological was reached in the scientific classification of animals. Concise descriptions of animal life and dry enumeration of physical characteristics took the place of vivid accounts of their habits of life. Botanies dealt with anatomical structure of plant life. The aim seemed to be an encyclopaedic grasp of the physical constitution of the animal and plant species. Anatomical structure ousted comprehension of the functioning of life. Textbooks were compilations of technical terms and minute texts of classification. Authors in revising them were more concerned to include the latest classification of animals than they were to give a broad understanding of the natural science world.[4]

The early secondary-school science textbooks were largely abbreviated college texts. The first year out of college the writer taught a class of high-school botany. The adopted textbook was written by the author of a college botany text. The same general outline was used in both books; in fact, the two books were the same except the high-school text had been abbreviated and simplified in a few places.

The nomenclature hodgepodge was attached to the first general science textbooks due to the fact that the authors would combine sections of the various special

[1] Phillips, Frank M. "Textbooks in American Schools." *School Review* 38: 167; March, 1930.

[2] Bacon, Paul V. "The Textbook as a Course of Study." *American School Board Journal* 90: 44; June, 1935.

[3] *Ibid.*, p. 44.

[4] Rugg, Harold O. *The Twenty-Sixth Yearbook of the National Society for the Study of Education*, Part I. Public School Publishing Company, Bloomington, Illinois, 1926. p. 22–28.

sciences and call this abnormal hybrid a textbook. In discussing the organization of the early general science textbooks Frank says,

> All of them were made up of larger or smaller units of each of the special sciences, simplified and to some extent "denatured." All were organized on the basis of science itself, not on the basis of the pupil's interests or needs, or on the basis of the teachability of the material selected. Each book reflected the training of the author, by the stress put upon the field with which he was best acquainted.[5]

The secondary-school textbooks of today are great improvements over those of a few decades ago. Within the last half century it was not uncommon to find the subject matter instead of the pupil the center of the teaching process. In 1910 Thwing[6] said, "The fundamental change wrought in the textbook . . . is that it is written for the purpose of teaching the pupil and not for the purpose of presenting a subject." Regarding this phenomenal change in our textbooks the committee of the *Thirtieth Yearbook* of the National Society for the Study of Education adds,

> The modern textbook, such as is used in the public and private schools of this country, is the most striking example of positive improvement in educational equipment and procedure in a generation of notable progress in the development of a general educational program. It is at once the expression of the best thought in methods of teaching and the best art and skill in mechanical production of a nation of unquestioned leadership in these lives of endeavor.[7]

The American textbook has had distinctive characteristics from the early beginning of this republic. Special interest in these books by our educators has added impetus to their improvement until "today the American schoolbook is the most interesting, the most effective, the most beautiful in the world."[8] Baird[9] speaks very highly of our general science textbooks in the following words, "It is doubtful if better texts are written for the junior-high-school level than are the general science texts that are available today."

School administrators and teachers have a tremendous influence upon the type of textbook sold. The better textbooks are written and published with the aim of meeting the requirements of these persons. Since textbooks are produced chiefly to be sold, then the public is directly or indirectly responsible for their improvement. Whipple says,

> Successful textbooks reflect the mores, the cultural level, the academic demands, and even the pedagogic fashions of the times. These cultural items, demands and fashions are embodied most clearly in the courses of study current at any given period, and hence the content of textbooks and the style in which these are set forth are obviously and openly dictated for both authors and publishers.[10]

The textbook is one of the most important devices, if not the most important, which is used by teachers and pupils in the educative process. The authors of the *Thirtieth Yearbook* of the National Society for the Study of Education[11] say, "There is a general impression that the textbook very largely dominates classroom instruction in American schools. . . . It is the textbook that in thousands of classrooms determines the content of instruction as well as the teaching procedure."

Caswell and Campbell have strong convictions concerning the dominant role of the textbook in our schools. They say,

> Traditionally, scope of work in American schools is determined by the organization and

[5] Frank, J. O. *How to Teach General Science.* Oshkosh Castle-Pierce Press, Oshkosh, Wisconsin, 1925. p. 17.

[6] Thwing, Charles F. "The Improvement of the Text-Book." *The Nation* 90: 424; April 28, 1910.

[7] National Society for the Study of Education. *Thirtieth Yearbook, Part II—The Textbook in American Education.* Public School Publishing Company, Bloomington, Illinois, 1931. p. 221.

[8] Branham, Alfred I. "The Development of the American School Textbook." *American School Board Journal* 81: 58; August, 1930.

[9] Baird, William Jesse. "Suggestions for Improving Instruction in General Science." *Educational Administration and Supervision* 18: 104; February, 1932.

[10] Whipple, Guy M. "Are the Contents of Textbooks Dictated by Propagandists?" *The Nation's School* 12: 21, October, 1933.

[11] *Op. cit.*, pp. 1–7.

content of textbooks. When a school system adopts a text the tendency is to assume that the organization and materials of the text represent the work that given classes should cover. The traditional concept of teaching—covering a specified number of pages in the text—is a part of this general attitude of reverence for the textbook materials and organization.[12]

Judd [13] is very emphatic regarding the importance of the textbook. He expresses it in these words, "There is no influence in American schools which does more to determine what is taught to pupils than does the textbook." Regarding the influence and use of the textbook, Hopkins [14] says, "For the past hundred years the textbook has been the most important single tool which the teacher has used in her work. It has defined for her the meaning of education, methods to be used, and the outcomes to be expected."

No sane person engaged in education would be willing to discontinue completely the use of textbooks. They serve the teacher and pupil advantageously. Briggs [15] says that the importance of textbooks has long been recognized. "They present in convenient form much that pupils must learn, thus saving the time of the teacher, and they often include much valuable method." Curtis has summed up some of the important arguments heard in support of the present textbook system of teaching. They are:

A textbook is definite; it is maximally convenient; it safeguards the under-prepared teacher, making it possible for her to direct the class over the required work with considerable assurance; it is economical of time and effort, on the part of both the teacher and the pupil; it makes a uniform course for a city or a whole state.[16]

In reviewing courses of study a person occasionally finds one that has been constructed around a textbook. The General Science Course of Study for a large city in Kentucky which was adopted in 1932, is an illustration of this procedure. In one of our southern states the Department of Education [17] goes so far as to print in the "Foreword" this statement: "Following the recent textbook adoption, we find it necessary to revise our High School Manual. This has been done after a careful study of the new texts in the State Course of Study."

Educators seem to agree that the text should be as consistent as possible with the course of study. Harap [18] claims, "A text is auxiliary to a course of study and its selection depends upon the content of the latter." But some textbook enthusiasts would place the text before the course of study. Bacon [19] proposes that the textbook should be the course of study. In discussing this idea he says, "Most textbooks today are the result of careful, scholarly study by practical teachers who have thus embodied in concrete, teachable form the principles that seem to them to make up the ideal curriculum. Thus the textbook is a kind of standardized test of the course of study."

In a survey of the teaching of general science, the writer divided the United States into five geographical divisions, and two states were selected from each division. Three schools from each of these ten states were studied, one of which was a secondary school in a large city, the second one was

[12] Caswell, Hollis L. and Campbell, Doak S. *Curriculum Development.* New York: American Book Company, 1935. p. 142.

[13] Judd, Charles H. "Analyzing Textbooks." *Elementary School Journal* 19:143; October, 1918.

[14] Hopkins, L. Thomas. *Curriculum Principles and Practices.* Chicago: Benj. H. Sanborn and Company, 1934. p. 564.

[15] Briggs, Thomas H. *Secondary Education.* New York: The Macmillan Company, 1934. p. 363.

[16] Curtis, Francis D. "More from Our Textbooks." *School Review* 30:771; December, 1922.

[17] South Carolina Public Schools. *High School Manual.* State Department of Education, Columbia, South Carolina, 1927. pp. ii.

[18] Harap, Henry. "Education of Curricula and Texts." *Review of Educational Research* 1:44; January, 1931.

[19] Bacon, Paul V. *Op. cit.* p. 44.

a high school in a city of medium size, and the third a secondary school in a rural area. Similarly, Kentucky was divided into five geographical sections with three schools chosen from each section. A total of forty-five schools was studied.

The investigation of the writer reveals that general science teachers, to a very large extent, depend upon the textbook for the content of their course. In requesting the schools surveyed to check the units which make up the content of their course in general science, many of the schools inferred that they follow the adopted text. One superintendent replied as follows: "Units treated in text cover work offered in courses." The *Thirtieth Yearbook* of the National Society for the Study of Education [20] states that the beginning teacher, whatever his training, will depend upon the formal textbook methods more than teachers with experience.

In 1925 Gruenberg and Wheat [21] made a study of the trends of general science in which they discovered that in more than four-fifths of the schools investigated the teachers depend upon the textbook for what they teach. They sum up their survey as follows: "That the textbook plays a prominent role in determining the content of instruction appears from the fact that only 13 per cent of the schools (studied) claim to disregard the textbook entirely in determining what they are to teach."

In a recent book Maxwell and Kilzer agree with the preceding author. They say,

> Few teachers are competent to collect and organize all the instructional material requisite for the courses they teach. The textbook, therefore, has become an important, even a necessary, tool in instruction. Too great dependence on the textbook, however, is not desirable; in fact, it may prove a reflection on the ability of the teacher. The teacher must realize that the textbook seldom fills the whole need. Not only must the text itself be adapted to the experiences of the pupils in any particular class, but generally it must be supplemented if instruction is to achieve the objectives set up.[22]

Baird [23] thinks that general science teachers depend upon the textbook more freely than teachers of other subjects. He says they use "The textbook recitation method with an 'I must finish the book' attitude toward the subject matter."

Since textbooks are so important the utmost care should be observed in their selection. There has been some evidence of personal greed and politics in the selection of school books. In discussing such practices an editorial writer [24] in the School Review commented as follows: "The content of class books used in our schools is by all odds the most potent force in our public education. Textbooks ought to be accurate in fact and principle, ought to be supplied in liberal numbers to the pupils, and ought to be selected by educational experts, not by political school boards."

The schools in the United States are maintained for the children of all the people; therefore, the public schools are operated for the pupils. Selfishness has no place in the business transactions of the school. The educational interests of the pupil must at all times be the primary consideration in appraising plans for both making and selecting textbooks. Edmonson [25] in The *Thirtieth Yearbook* of the National Society for the Study of Education says, "We are led to believe that the standards of practice in the marketing and selection of textbooks have been lifted appreciably in recent years."

[20] Edmonson, J. B. (Chairman). *Op. cit.* p. 25.

[21] Gruenberg, Benjamin C., and Wheat, Frank M. "The Trends of General Science." *School Science and Mathematics* 24: 859, November, 1925.

[22] Maxwell, C. R., and Kilzer, L. R. *High School Administration.* Garden City, New York: Doubleday, Doran and Company, 1936. p. 370.

[23] Baird, William Jesse. *Op. cit.* p. 104.

[24] Editorial. "Three Types of Textbook Trouble." *School Review* 30: 85–87; February, 1922.

[25] National Society for the Study of Education. *Op cit.* p. 220.

Some specific method of analysis should be employed in the selection of textbooks for secondary schools. Eight different methods of such an analysis are listed by Weber as follows:

(1) A cursory, rather superficial personal analysis with reference to a few general rules, admonitions and reminders, or to a list of desirable qualities to be sought in any textbook. (2) A ranking and averaging personal judgments based upon specific qualities to be sought in textbooks on some particular subject. (3) Arriving at the score of individual personal judgments by fixing weights or values to certain specific features of textbooks. (4) Making a careful impersonal analysis of textbooks in order to arrive at comparative data to be used in determining the worth of any book for classroom instruction. (5) Checking a careful impersonal analysis against the clearly practical demands of life as shown by a survey of human activities. (6) Scoring a careful impersonal analysis on the basis of a previously accepted standard of curricular content. (7) Actual class use. (8) Arriving at a summation of ranks based on the one hand (1) on expert opinion of the worth of the content of the textbook as shown by a careful impersonal analysis, and, on the other hand, (2) on personal judgments based largely on class use.[26]

The prevailing practice among the various states is to have a compulsory or approved textbook law. The chief disadvantage of such a law is that it may not permit enough freedom to certain school communities in the selection of the textbook which is best adapted to their local needs. The present tendency is to permit a certain amount of prerogative to schools in their selection of textbooks. When state uniformity of textbooks is provided, provision should be made for a liberal supplementary list of textbooks permitting local authorities to exercise a good deal of freedom in their selection.

A BRIEF SURVEY OF TEXTBOOK ANALYSIS

The scientific analysis of textbooks dates back more than two decades. Phelp [27] says that one of the earliest textbook studies was an analysis of history texts by Bagley and Rugg in 1914. Monroe [28] was another pioneer in the analysis of textbooks. In the *Sixteenth Yearbook* of the National Society for the Study of Education he reports the analysis of four textbooks in arithmetic.

A number of analyses of general science textbooks have been made. The most important ones are given in chronological order. In 1920 Trafton [29] analyzed seventeen general science textbooks to determine the distribution of subject matter among seven of the large science groups. He found that the amount of space in the general science textbooks devoted to seven special sciences ranked as follows: (1) Physics, (2) hygiene, (3) physical geography, (4) biology, (5) chemistry, (6) agriculture, and (7) astronomy. He says that twelve textbooks devoted the most space to physics, two to hygiene, two to physical geography, and one to agriculture.

The analysis of textbooks by Webb [30] in 1921 is the one most often mentioned. He made a quantitative analysis of eighteen general science textbooks to determine the distribution of subject matter among the major sciences. He worked out the relative number and importance of the topics composing these major sciences. These sciences ranked as follows: (1) Physics, (2) physiography, (3) biology, (4) physiology-hygiene, (5) chemistry, (6) household arts and sciences, (7) astronomy, and (8) miscellaneous. He classified the total amount of subject matter in each of the above groups both by pages and by topics.

[26] Weber, Oscar F. "Methods Used in the Analysis of Textbooks." *School and Society* 24:678; November 27, 1926.

[27] Phelp, Ethel L. "An Analysis of Textbooks in Clothing and Textiles." *Journal of Home Economics* 14:471; October, 1922.

[28] Monroe, Walter S. "A Preliminary Report of an Investigation of the Economy of Time in Arithmetic." *Sixteenth Yearbook of the National Society for the Study of Education,* Part I. Bloomington, Illinois: Public School Publishing Company, 1917. pp. 111–127.

[29] Trafton, Gilbert H. *Op cit.* pp. 450–452.

[30] Webb, Hanor A. *General Science Instruction in the Grades:* Part I. (Contribution to Education, No. 4), George Peabody College for Teachers, Nashville, Tennessee, 1921. pp. 1–40.

In 1922 Weckel[31] made a careful analysis of ten general science textbooks to determine what basic aims, underlying scientific principles, and fundamental concepts occur most frequently in these textbooks. She found the content of general science textbooks uniform. She concludes, "This uniformity is due, I believe, to the fact that the authors are agreed on the dominant aims and purposes of the subject."

In 1927 Klopp[32] analyzed nine textbooks in general science. He determined the amount of space devoted to eight specific sciences. These eight sciences with the total average rank for the nine books were as follows: (1) Physics, (2) biology, (3) physical geography, (4) physiology, (5) chemistry, and (6) astronomy. Among the conclusions reached he decided that the authors of general science textbooks did not always agree upon the type and the amount of content in their books.

A year after Klopp make his study, Downing[33] reported two analyses of general science textbooks which he combined from Masters' theses. In 1921 O. E. Overn analyzed twelve textbooks and in 1927 Ernest Iler analyzed thirteen more which had been published since the analysis by Overn. These two persons wished to determine the content of general science textbooks. Their surveys differed from the previous ones mentioned in that the content was analyzed on the basis of twenty large topics or units subdivided into 131 minor topics. The titles of the large topics, arranged according to their rank, are as follows: (1) Mechanics, (2) weather and climate, (3) plants, (4) electricity and magnetism, (5) bacteria and sanitation, (6) water, (7) heat, (8) food, (9) light, (10) human body, (11) earth as a planet, (12) combustion, (13) elements, compounds and mixtures, (14) life in general, (15) lower animals, (16) air, (17) rocks, (18) weathering and erosion, (19) sound, and (20) household chemistry. Downing concludes that, "There is no concensus of opinion as to what should be treated in a text in general science and that there has been no increase in the unanimity of opinion in this matter in the late books as compared with the earlier ones."

Another study of general science textbooks was reported by Heineman[34] in 1928. She analyzed twenty general science textbooks in order to discover how much importance was accorded to the principles of science. She found ninety-three principles and over two thousand applications to these principles. In concluding she states that among the many general science textbooks one built on principles was yet to be written.

Chappelear[35] made an analysis of twenty natural science textbooks to determine the amount of health material present. Of this list of twenty books, five were general science texts, and were published between 1924 and 1927. He found that the five general science textbooks devoted 30.78 per cent of all subject matter to health content. He says that the health content of general science textbooks is well distributed over the most important classifications of health subject matter.

In 1931 Davis[36] made a qualitative

[31] Weckel, Ada L. "Are Any Principles of Organization of General Science Evidenced by the Present Textbooks in the Subject?" *School Science and Mathematics* 22: 44–51; January, 1922.

[32] Klopp, W. L. "A Study of the Offerings of General Science Texts." *General Science Quarterly* 11: 236–246; May, 1927.

[33] Downing, E. R. "An Analysis of Textbooks in General Science." *General Science Quarterly* 12: 509–516; May, 1928.

[34] Heineman, Ailsie M. "A Study of General Science Textbooks." *General Science Quarterly* 13: 11–23; November, 1928.

[35] Chappelear, Claude S. *Health Subject Matter in Natural Sciences.* (Contribution to Education, No. 341), Teachers College, Columbia University, New York, 1929. pp. 4–13.

[36] Davis, Ira C. "Analysis of Subject Matter in the Eight Most Widely Used Textbooks in General Science." *School Science and Mathematics* 31: 707–714; June, 1931.

analysis of eight most widely used general science textbooks in order to determine their content. He divides the content into fifteen units then subdivides these into 137 topics. These units are: (1) Air, (2) water, (3) heat, (4) weather and climate, (5) light, (6) sound, (7) magnetism and electricity, (8) energy and machines, (9) solar system, (10) rocks and soils, (11) plants, (12) animals, (13) human body, (14) foods, and (15) clothing. Among his conclusions he states that our leading textbooks in general science agree on subject matter. He found over 96 per cent of the subject matter material in at least six of the eight textbooks.

In order to determine the sex differences in the comprehension of general science, Smith[37] made a survey of ten textbooks which were edited between 1925 and 1930. He chose 478 statements from commonly adopted textbooks, then he analyzed ten general science textbooks to discover the extent to which these statements had been incorporated into these books. One hundred fifty of the 478 statements were used by every author. Regarding the content of general science textbooks he says, "Textbook writers agree least on plants and animal biology, on biographical material and on foods and clothing. They agree best on heat, electricity and weather."

In 1935, Wolford[38] analyzed eight general science textbooks to determine both the content and the organization of subject matter. He based his analysis upon eighteen units or major topics subdivided into 180 topics. The units are ranked according to the average percentage of space devoted to them. They are as follows: (1) Mechanics, (2) health, (3) heavenly bodies, (4) heating the home, (5) food and diet, (6) weather knowledge, (7) lighting the home, (8) electricity, (9) recreation, (10) farming, (11) home in general, (12) water supply, (13) life in general, (14) ventilating buildings, (15) plants, (16) animals, (17) milk supply, and (18) fire protection. He concludes that an analysis of general science textbooks gives evidence that no attempt has been made to prepare a textbook that is especially adapted to a particular region.

One of the more recent reports of the analysis of general science textbooks was made by Simmons[39] which covered twelve general science textbooks. The four most recent ones were copyrighted from 1930 to 1934. The content of these four books was divided into sixteen major topics or units. These units are listed below according to their rank, based on the amount of space devoted to them, as follows: (1) Health, (2) water, (3) machines, (4) heat, (5) planets, (6) weather, (7) electricity, (8) plant life, (9) air, (10) soils, (11) light, (12) animal life, (13) energy, (14) sound, (15) matter, and (16) forces of nature. He analyzed the general science textbooks in order to determine their content during three different periods of time.

[37] Smith, Victor C. "Sex Differences in the Study of General Science." *Science* 75: 55–57; January 8, 1932.

[38] Wolford, Feaster. *Methods of Determining Types of Content for a Course of Study for Eighth Grade Science in the High Schools of the Southern Appalachian Region.* Unpublished Doctor's Dissertation. Cornell University, Ithaca, New York, 1935. pp. 63–87.

[39] Simmons, Maitland P. "Changing Conceptions of Major Topics in General Science Textbooks." *Journal of Educational Research* 31: 199–204; November, 1937.

(To be concluded in the February issue)

WHAT KIND OF ACTIVITIES IN SCIENCE?

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It is indeed a pleasure to be here this morning to consider with you some problems relating to the teaching of science. I appreciate that among you are teachers of the various branches of high school science. Accordingly I have tried to think of what I might say that might be of some interest and of some practical help to each of you, regardless of what particular aspect of science or what grade level you might be teaching.

We have long been told that we learn to do by doing and that it is the business of the school to set up situations in which students will have experiences that will lead to certain outcomes. We have built our courses around student activities. And we as science teachers have considered the subject that we teach as lending itself particularly well to a variety of activities by students. But of course there are activities and there are activities. What kind of activities do we want our students to engage in? It seems but common sense to say that we want them to engage in those activities that will result in the *outcomes* we seek, activities that will result in *growth* in certain particular skills or attitudes or methods or ideas or abilities.

I think (at least I hope) that there is pretty general appreciation among us that science has much more to offer than knowledge, organized and systematized, and learned as dogma: there is more than learning all about science, and there is more than merely teaching about science. But we still have far to go as a group if we would make activities constitute significant experience. We have an opportunity to bring students to a feeling about the methods of science, and understanding of these methods and attitudes, an understanding based upon their own experiences in using the methods of science. And of course, back of the overt behavior involved in the methods there are the purposes and the thinking that precede and accompany method. We can teach science with the very definite purpose of increasing the student's ability and disposition to think straight, to think impersonally, to think without emotion or bias, to be tolerant of the ideas of others, to select related ideas, to discard irrelevant ideas, to keep a mind open to additional facts, to be willing and able to give up preconceived ideas that do not harmonize with observed facts, to set up hypotheses or suppositions, to test, alter, discard, or tentatively accept them, to arrive at conclusions that are in harmony with facts. We have the opportunity to develop in students increased ability and increased inclination to think and to act and to feel in the way or ways that we like to think of as the scientific method and the scientific attitudes.

Psychologists tell us that attitudes are emotionalized outcomes of experience, that they are the byproducts of learning that pre-dispose one to behave a particular way in a situation as a result of previous experiences. They tell us that to learn, one must experience; indeed he must reconstruct each experience and incorporate it into his total personality pattern. He must live the experience. How often have we teachers remarked that we never really knew some subject until we had taught it! Surely if we wished to have our students learn the skills involved in swimming or playing a piano we would do more than have them learn all they can about swimming or piano playing—though we might do that too—at the appropriate time; and

we would have them do more than "practice."

No, if we want to teach science in such a way that there will be vital experiences of the kind suggested above we shall have to do two things. We shall have to be very clear in our own thinking as to exactly what outcomes we want to achieve and very earnest in our own feeling that these outcomes are of vital significance. Then we shall have to arrange situations—set the stage, if you like—so that students will have such experiences as will result in the outcomes we seek. (Of course, if we want to know how good a job we are doing in achieving our purposes we shall have to construct tests that are designed to measure these outcomes, and not information alone, as tests still predominately do.)

If then we are agreed that we want our students to be increasingly disposed and able to use the so-called methods of investigation, and assume the scientific attitudes, and to think reflectively, we must arrange situations in which they practice these skills and experience the procedures and feelings under guidance. Such situations must be essentially problem situations. Now there are two kinds of activities involved in problem situations; there are the techniques connected with raising problems, and there are the techniques connected with solving problems. And students must become increasingly able to do both effectively.

The proceedures commonly used in schools make the pupil quite passive in this first aspect of problem solving. The teacher assigns problems or he assigns pages in a textbook in which the problems are stated. The student is not stimulated to discover and work at problems through his own initiative and thus he is deprived of the first essential for creative thinking. Such a procedure can hardly prepare students to face problems in life intelligently since by it they do not learn to recognize any except assigned problems.

It is through participation in purposeful activity that pupils can develop problems of their own. But activity alone does not guarantee that problems will arise in such a fashion that they will be adequately investigated. The teacher must assume a questioning, skeptical attitude, even regarding matters that seem to be settled when judged from the mature point of view if he would stimulate similar attitudes in pupils.

In this connection let me quote Professor Bayles:

> "The search for educationally suitable topics or problems is one of finding basic disagreements or conflicts in our previously accepted way of looking at one's world. Moreover, this would mean not only immediately evident conflicts, but also vagueness or inadequacies which might involve interpretations which are in conflict; conclusions which are not in harmony with accepted facts, ideas which run counter to one another, or ideals and practices which do not jibe. What is more conductive to the reconstruction of one's way of looking at the world than the discovery of incompatibilities in one's previous acceptances? Truly one cannot be at peace with one's self until conflicts are removed and harmony is restored. Just as a musical dissonance must be resolved before the listener is at ease, so must an intellectual conflict be harmonized before the normal individual can rest content. . . . The technique of raising problems, while varying as widely as do the experiences in life itself, seems to be primarily one of *unsettling the settled nature of things.* So long as we are dealing with settled matters we cannot be dealing with problems, for a problem arises only when a human mind becomes convinced that its present beliefs, habits, or patterns of conduct are inadequate." [1]

In recognition of the historical fact that science has emerged out of the practical and theoretical "dissonances" we may accept this point of view as being psychologically sound. It then becomes the teacher's responsibility to help students to bring out into the open those "conflicts" and "vaguely felt inadequacies," to guide students in framing problems, in defining

[1] Bayles, Ernest E. The Social Significance of Science Teaching. *Proceeding of Meetings Held at Denver July 1–3, 1935. Department of Science Instruction, National Education Association.*

them, and in limiting their scope. Perhaps the most difficult aspect of problem raising is the ability to state just what the problem is, for a problem well stated is half solved. This process of limiting and stating problems of course takes time. It is so much easier and requires so much less time for the teacher himself to refine and state the problem growing out of a discussion, and for the students merely to accept it. For by this procedure the teacher may feel that he may "cover so much more subject matter," that is, he can expose the student to so much more information to be accepted and learned. But of course we are not primarily concerned with this kind of subject matter. Nonetheless, there seems to be adequate evidence that when students get interested in solving real problems the time taken as suggested above is more than made up by subsequent acceleration through deeper insights, and through reading both more effectively and more widely than they would otherwise do.

I do not wish to imply that mimeographed or printed workbooks or guides to learning have no place in science teaching. If we are realistic we must recognize the necessity for varying degrees of systematization. These guides to activities seek to circumvent though they cannot prevent the obstacles to our best work. Even where these devices are used the teacher through skillful questioning and class discussion must direct the thinking of the class to the end that the problems students seek to solve have indeed become their own problems. And of course the guides should be designed to challenge the student's thinking in selecting means and devices for solving his problems rather than laying out each step in cook-book fashion.

Once the student, or the class, has defined and limited the problem, he must map out a plan of procedure designed to solve it; that is, to answer the question which his problem poses. He cannot simply begin to experiment or to make observations or to read.[2] He must think through the problem, he must create and consider various alternate possibilities; that is, he must set up an hypothesis. Now, hypotheses do not come out of a hat or out of thin air. To formulate an hypothesis requires creative thought. There is probably little that the teacher can do directly to influence the ability to find possible solutions. In general this ability seems to depend upon the student's previous experience and education and upon his general mental level. However, students at all levels are eager to suggest "explanations" or interpretations or hypotheses. Generally, of course, these are in terms of previously "learned" principles or special "facts," sometimes, however, from analogies to personal observation or experience. Rarely should we expect a useful "original" hypothesis. The teacher can encourage the formulation of students' thoughts, not search for original solutions, and this is an essential and valuable part of the "activity." It is "creative" even when precisely the same ideas had been previously formulated by countless others.

If we may assume that the problem is not beyond the student's level of ability and is yet of sufficient difficulty to challenge his best efforts, he should be encouraged to state various hunches or guesses and write them down. If, as is likely, the problem is one which is being considered by the class as a whole, the teacher will encourage the class to suggest various possibilities.

[2] The authors of a recent biology book say: "All scientific knowledge is gained through the use of scientific method. *Scientific method begins with accurate observation.*" (My italics.) On the contrary. It begins with beliefs and assumptions derived from more or less inaccurate and quite incomplete and often irrelevant observations. On such beginnings people arrive at the point of needing to agree (whether with one another or with the recalcitrant and stubborn world, which refuses to behave according to such beliefs and convictions and laws and "observations" as they had brought to this point). This failure of observations eventually creates "problems." THAT is the beginning.

These should be considered by the class. Through appropriate questioning the teacher guides the class to examine the various proposals critically. He encourages the students to evaluate the suggestions, to alter them, and to discard those that seem to be unsuitable or irrelevant in the present situation. The attitude of the teacher will largely determine the extent to which students will keep open minds and will follow leads objectively, irrespective of preconceived ideas. Students can be directed toward considering proposals on their merits, think them through reflectively, and discard them or accept them as their thinking guides them; but they will be hindered rather than helped by the teacher who sets himself up as an authority and arbitrarily rejects this suggestion or that one as being "wrong" or inadequate or silly, or who by his facial expression or his manner gives a cue to his own thinking. The teacher, we may assume, knows the commonly accepted hypothesis or the appropriate one upon which it is desirable to proceed. But he must be prepared to keep this to himself, and to direct the thinking of students through the raising of questions, so that they may learn to think reflectively.

Let us assume then that various suppositions have been proposed and evaluated by the class and that after careful consideration of the end to which they would lead, the class has set aside all but one which they propose to accept tentatively, one that seems the most likely to lead to a solution of their problem. Let us assume too that students are prepared to test out their supposition but that they are also prepared to discard it and to substitute another in the event that it does not stand the test. They are now at the point where they must suggest and consider ways and means of putting their hypothesis to a test.

Here again suggestions will be welcomed and will be offered by the class. The teacher will skillfully direct the thinking of the class in its consideration and evaluation of suggested procedures. How are they to test their hypothesis? What constitutes a solution of the problem? What constitutes evidence? To what source or sources shall they go? To books? To what books? To authorities? What constitutes an authority? Is Dad an authority? Is the teacher? Is a priest? Is the newspaper? Or shall they go to the facts themselves? Shall they make firsthand observations of things and of happenings? Shall they set up conditions so that they can test for themselves, that is, experiment, in a real sense? How can they plan action for resolving conflicting views and suppositions? How can they be sure that their experiment tests what it is designed to test? What control needs to be set up? What factors must be kept uniform and what factor is the variable? And so on and on.

I find among college students a surprising lack of disposition or of skill in doing such simple things as observing through their own eyes and recording accurately the changing position and apparent shape of the moon on consecutive nights, or the positions of planets with respect to constellations during an interval of several weeks. They would rather read about it, learn it, and re-cite it. Apparently by this time they have found a premium upon final answers. Young children are curious about almost everything around them. It is not difficult to get them to see what happens or to raise questions. It is too bad that adults spoil them by making them docile getters of information from printed pages. (In saying this I am not suggesting that books have no place in teaching; quite the contrary. I am simply saying that if youth is to keep awake to what goes on around us, if they are to remain curious, if they are to learn to solve problems, they must learn to go to actual behavior and observe, measure and record facts of nature

—accurately and patiently, with open minds and without prejudice. Then they must learn to recognize the distinction between observed facts and theories or beliefs about them.)

Perhaps it will be helpful to take an illustration to make clear just what I mean. Suppose that in a class discussion a student wants to know why sometimes there seems to be more scum on soapy water than there is at others. Now of course the teacher could at this point himself define the problem, tell how to solve it, and indeed give the answer. Or he could send the student to a suitable book to find the answer for himself. And of course there are times aplenty when such a procedure is justified, for we cannot take the time to solve at first hand all our problems. We must also find the answers from those who are qualified to give the answers. But if we want to teach students to practice the habits of reflective thinking, and use of the scientific methods, and to approach problems with the scientific attitudes, we must provide situations in which they can acquire and practice these skills and in which they are consistently encouraged to assume these attitudes. Suppose then that we decide that this situation furnishes such an opportunity.

Through discussion we bring out that some of the students have consistently noticed at home that there is scum on the water when they use soap. Others say that they have not noticed it. Perhaps one student may contribute the fact that at home they add some liquid or powder to the water before using soap and that this results in no scum. Another student disputes this and says that there is just as much scum but that less soap is needed to form suds. Another says it depends upon the kind of soap you use. Another says, no, it is the kind of water, and cites experience as evidence. Still another says that they formerly had to use a "lot of soap" but since they got a water-softener they don't use nearly as much. One says that the waters that form more scum also require more soap before suds will form.

What is the problem? The class is not in agreement as to the facts. And the contributions made by students vary in degree of relevancy to the question first raised. How can we frame our question so that we may go about it systematically to find the answer? Perhaps some student will put forth the idea that before we can find why waters differ in the amounts of scum they form they must first know what causes scum. Or the teacher will raise the question: what must we know about scum on water before we can find why more or less? And if that does not lead to a fruitful answer, he may ask: Can we find out why more or less before we know what causes scum? Some will at once see the reasonableness of this and will say: yes, before we can find out why some waters form more scum we must find out what causes scum in the first place. To some members of the class this will not be so obvious. What, then is our problem? We find that we have two problems instead of one. First, we must find out what causes scum to form on water when soap is added. Then perhaps when we know the answer to this question we may be able to find why waters differ as to the amount of scum that forms when soap is added.

If this is accepted by the students of the class as their problem, then we may ask: How shall we proceed to find the answer? Many suggestions will be forthcoming. These may be evaluated by the class. Through this process of suggesting, evaluating, altering, discarding, accepting, the class finally arrives at the idea: Test water from different sources—tap water, cistern water, water from private wells, distilled water. How much of each shall we use? Does it matter whether or not we use equal amounts? Why or why not? What about the temperature? May this vary or should it be uniform for all the waters tested?

Why or why not? How about the soap? What kind of soap shall we use? Or may we use different kinds of soap in different waters? Why or why not? And how much soap shall we add at a time? And how do we know when we have added enough soap to complete our test? We raise questions. We consider alternatives. Students are relating ideas; they are evaluating ideas; they are comparing ideas; they are rejecting ideas; they are accepting ideas; in fine they are thinking; they are reflecting. And the teacher is guiding their thinking. He is setting the stage—arranging the learning situation—so that the students will engage in activities that lead to growth in ability to think clearly and logically in terms of a situation that is real and that is dynamic.

So the students go to work to test their hypothesis that scum is formed by the action of soap on the solutes in water. We have not the time here to follow through these activities. It is enough to say that since this is their own problem and not the teacher's or the author's, and since they have thought it through themselves, they will understand what they are doing and why they are doing it. As a result of their tests they conclude that scum forms only in water in which is dissolved certain foreign matter; scum does not form in water that contains no dissolved matter. Therefore they *infer* that it must be the action of soap on matter dissolved in water that causes scum. And they also conclude, tentatively, that the amount of scum found must be related to the amount or the kind of substance dissolved in water. This is of course another supposition, one which students may wish to test, should their background be adequate.

In the illustration that we have considered, let me for emphasis call attention to several things that have happened—and to things that did not happen. Students were not given a laboratory manual with lists of problems already stated in a form suitable for solving and accept them without question. Minute directions were not given for students to follow through step by step in getting the answer to the printed problem. Students did not go ahead and blindly manipulate materials and apparatus without knowing what they were doing or why, as they would put together the ingredients for making a cake by blindly following a cookbook. Someone else did not do their thinking for them. True enough, individual students in class may have made no contributions in class. Still each has at least had the opportunity to listen and to follow the thinking that went on during the discussion. Each has had a chance to see how a problem is set up in such a form as to facilitate solving. They have participated in suggesting and selecting working hypotheses. They have accepted a general plan for "testing" that involves special acts of measuring and recording. They have set up controls in their proposed tests, keeping uniform all factors except one. They have individually or in groups made the tests. They have compared their findings with those of others. They have found an answer to the question with which they started. They therefore arrive at a conclusion or an inference that seems to be in harmony with the facts, some of which were previously known, others newly discovered. They accept the findings and the conclusion regardless of whether this conclusion is in harmony with their previous ideas regarding the matter. They go to authorities—to books—to read for the purpose of checking their thinking and their findings against those of more mature and more skilled students. And in the solving of the problem other problems have arisen that make them eager to go ahead and solve further. They have learned facts. They have acquired information. But how much more they have! Perhaps they have become sufficiently stimulated to raise

questions the solution of which calls for more experimentation and more knowledge than is now available, questions which will require further background through reading or investigation. So they go to reference books, to textbooks, to encyclopedias, to periodicals. Or they make an inspection of some commercial or municipal establishment and report upon it orally or in writing. Their curiosity has been aroused, their imaginations have been kindled, their areas of observation expanded, their skill in problem raising and problem solving definitely improved. They have firsthand information, firsthand experience that enables them to speak and to write effectively because they have something to express that has immediate personal meaning. They have indeed had experiences that will add to their effectiveness as citizens.

With continually recurring similar activities throughout their several years of work in science students will acquire mental and emotional equipment that will be of help to them long after they have forgotten many of the particular facts and principles and theories that they have learned. But they will also retain a much larger proportion of facts that they have learned and they will retain them much longer than if they had merely read about them, learned them and recited them. Learning has been vital; it has been dynamic; it has been incorporated into their very being and has become a part of them. They have not learned about science; they have *lived* science; they have felt science; they have thought scientifically; they have behaved scientifically. There is indeed science in their lives.

Editorials and Educational News

THE GODS OF SCIENCE

It would be desirable to adopt a new list of great scientists to be included in the teaching materials of functional science where scientific method, attitude, and skill are cultivated. Those whose names and pictures have been included in textbooks in the past are worthy of honor and have inspired pupils. It is a good idea to show honor to great scientists in our textbooks and we would eliminate some of them only to enlarge the idea and make room for even greater men.

We rate scientists in greatness on the importance of their contributions, of course. If we say that one man is a greater scientist than another, we refer not to his genius or lack of it, nor to the humbleness of his origin, nor to the obstacles he had to surmount, but only to the value of his discoveries. A stricken man who overcomes seemingly insuperable handicaps to make a minor contribution to science is a great character but not a great scientist. A slight acquaintance with the history of science confirms the point. Usefulness is, in fact, the world's criterion of scientific greatness.

If that much be granted, the rest follows very simply. For example, if Koch be great because he discovered the germs of tuberculosis, anthrax, *et cetera* (very useful knowledge), with his microscope, how much greater is the man who originated the microscope and thus made possible the great usefulness of not only Koch but also Schwann, Schleiden, Pasteur, Brown, and innumerable others! Again, if other scientists are great (and who can doubt it?) because of the discoveries they made using solid culture media, how very great is Koch because he first learned to raise microorganisms on the solid culture media of boiled potatoes! The more fundamental techniques and inventions open new worlds of discovery to the human race.

But let us not stop here; let us go back to a class of men whose work was even more fundamental, whose work was basic to the usefulness of even a Koch or a Von Leewenhoch. This is a class of men so useful that we may well call them super-scientists, or super-heroes, or the greater Gods of Science. The greatest of the great are those *who develop the scientific method itself* from which flow all techniques and inventions of research, and in turn, the already immense body of useful information of a more direct application in daily life.

In this list of the super-great I would include Socrates, the great skeptic. He questioned everything and induced clearer thinking. He is first both historically and logically—doubt is the beginning of wisdom. Also, Plato, the great logician. He developed constructive and systematic thinking which is essential for truth-finding. And then in Aristotle, the third of those I would like to honor as stars of the first magnitude, the human race began to collect specimens and facts, and learn that doubt and clear thinking alone are insufficient, that we must find out about things from the things themselves.

But by 1564 A.D. all but about one per cent of the writings of the ancients had been lost and most of the one per cent that remained had been perverted. There had been a thousand years of regression in scientific progress—the Dark Ages. Aristotle, who had shown that there are no authorities except the facts of nature themselves, had been set up as *the* authority on all things mundane. Honest doubt had again to rear its challenging head. Inductive thinking had never been worked out and had to be created. The facts of nature had again to be installed as *the*

authority on all things mundane. The controlled experiment, which was the next necessary step in scientific progress, had to be invented. Because one man was largely responsible for accomplishing all these things, I regard him, Galileo, as the greatest of the great Gods of Science.

A culture can be judged by its Gods and Heroes and ours is called a scientific age. But not only do we honor mostly the lesser Gods of Science, but we honor the greater Gods of Science for their lesser contributions. Galileo, the unsurpassed Galileo, is honored for such comparative trivialities as inventing the telescope and seeing spots on the sun! It is as though we were to honor Einstein in our textbooks with a photograph and the legend, "Einstien, Albert, American; Invented the Einstien Safety Brake for Baby Carriages!"

With these four I would place also: Newton, who taught us how to use the scientific hypothesis; Agassiz, who taught us how to train scientists by the hundreds; and Thurstone, who is now busy replacing factor-analysis-by-guesswork with factor-analysis-by-statistical-treatment.

These are surely some of the greater Gods of Science. Theirs are not petty discoveries and inventions; they give the invaluable SCIENTIFIC METHOD to man's groping and muddy mind. Super-Scientists, they teach and inspire disciples without number and thus multiply the usefulness of millions of lesser men. While the lesser Gods might be considered good enough for our lesser science courses where "useful information" is regarded as the only gift worth taking, in functional science courses we appreciate the greatest gifts of science to man: scientific method, attitude, and skill. It is seemly that we should most honor those who gave the greatest gifts: ours should be the greater Gods of Science!

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NEW AND PROMISING PRACTICES

On every hand one hears of challenging changes in organization, instruction, and evaluation in science teaching. It is our desire to bring to the attention of our readers descriptions of worthy innovations. Our readers are invited to send us for publication and editorial comment brief statements of their activities directed toward the improvement of the function and practice of science instruction. Statements should be limited to 100–500 words. Longer descriptions will be excerpted in this section of the Journal or will be considered as articles. Let us hear what you are doing.

An experience curriculum. The emerging curriculum has been through several stages. One thinks of the subject matter curriculum, the project curriculum, the problem curriculum, the activity curriculum, the experience curriculum, and so on. Probably a good "curriculum" in science includes elements and values from each of the various approaches and organizations. Certainly the spirit of the plan and the artistry of the teacher will make or break the educational potentialities of any "curriculum in science." A description of "an experience curriculum" received from George R. Biecher, Teacher of Biology, Chambersburg (Pennsylvania) High School, is so challenging that we quote his statement:

> Let us pause for a brief reflection in our science teaching to ask: If I were employed to watch a block of machines turning out a standard machine part, or knitting hose, or if perhaps to act as a nursemaid to an automatic machine lathe; would it really matter if there is a pair of nephric tubules in each segment of the earthworm? Would I be concerned about a molar solution of cupric chloride, or the conjugate foci of curved mirrors? Is it not true that our high school graduates will operate these automatic machines with little regard for the technical difficulties of the science laboratory?
>
> With this situation as a definite problem, the faculty of Chambersburg High School has been revising its curriculum. This does not mean that we have discontinued the training of college preparatory students. But it does mean that minimum requirements of the whole curriculum

attempt to prepare all the pupils to live well balanced lives. Then again we meet a challenge. We can not teach English, and leave chemistry, physics, or biology to the science department, or *vice versa*. A brief survey of the course in biology will serve to illustrate. Let us follow the correlation applicable to the problem of sex education in the course.

The Chambersburg biology student orients himself as a living animal by an imaginary world cruise. As to sex education, he has learned that he is an animal. If he is one of the less capable "non-academic" pupils, that is perhaps all that he will appreciate; so limited an appreciation being indictive of very few high school pupils. Furthermore, he will have completed the minimum requirements, designated as "x" activities, in "A Searching Party," the first unit in his course. It is also the first unit, in the first of seven "Experience Groups," bearing the group title "The Distribution of Life on the Earth." An academic or more capable non-academic pupil has taken "Extra Expense Tours," by the expenditure of greater effort in the same allotted time. Such a tour has involved more detailed ecological studies, designated as "y" or "z" activities. His ability has been challenged to capacity, but he has made the choice of his extra work. At the same time he may have become interested in ecology, geography, nature study, exploration, or a host of other avocational interests. He may have developed hobbies that broaden his sphere of life. Will sex consciousness disturb his anticipation for that avocational interest, when he leaves the automatic machine for the day? The average graduate will also enjoy his evening newspaper or magazine the more, because he has prepared a biological scrapbook of clippings, pictures, quotations, and poetry from these sources; also because he has used the vocabulary list accompanying the unit, in good English narration; or by his oral reports made from searching a comprehensive though not exhaustive bibliography of good popular periodical literature. Oral reports will have been experiences in self confidence and self respect, definite enemies of debased attitudes. If the English department cooperates in these reports, the individual will be a delightfully painless addition to social or conversational groups. Will you not agree also that such college students will have attitudes upon which to build the technical information of the laboratory?

To continue with the major divisions of the course, let us consider the remaining pupil experiences in sex education. The second "Experience Group" contains eight units under the title "Building a Museum." Here the first unit organizes a scrapbook into phylogenetic sections of clippings, pressed specimens, and pictures; with minimum appreciation of man's place in relation to other living forms. Succeeding units of the group include: Microscopic conceptions of structure, microbes as related to disease (including venereal diseases), insects, fish, amphibians and reptiles, birds, and mammals. The mammal unit entitled, "The Hall of Clever Furry Creatures," encourages an appreciation for viviparous pregnancy.

The third "Experience Group" organizes five units into a comparison of the human body with the organization of a democratic political state. In this group the unit on circulation entitled, "The Postal System," considers the endocrine glands (including the sex glands), as a special delivery system. The nervous system or final unit of this group is entitled "The State Government." In this unit there is ample opportunity for guidance when we have an activity called "The State Supreme Court," corresponding to the power of thinking and judgment to declare habits good or bad. Cooperation with the social science department will help to develop citizenship and practical appreciations during contemporary political upheaval, as well as the challenge to control personal choices.

In the seventh and final "Experience Group," the pupil experiences the development of sex under the title, "Passing Life Along." Unit I, "The Prelude to Life" is a progression from simple fission or cell division to viviparous sexual reproduction. In this unit the minimum appreciation illustrates that sex is nothing more than two cells called the egg and the sperm. The succeeding two units are an appreciation of the titles "The Future Generations" and "Circumstantial Evidence." These units represent guidance in the marital relation as heredity and evolution.

Has Chambersburg High discovered Utopia? Certainly not! The parable of the sower is as applicable today as it was two thousand years ago. But, it is the belief of the author that a high school faculty thus minded will definitely skew to the right the curve of Mendel's Law.

The community as a science laboratory. The effectiveness of instruction in science is in part dependent upon the degree to which the work of the classroom reaches outside into the community life and upon the degree to which the problems and work of the world are brought into the classroom. The study of science is a social undertaking. How one phase of this cooperation is brought about is reported by Principal C. C. Tuck, West Technical High School, Cleveland, Ohio, who says concerning the work in his school, described briefly in the following quotation, "These activities make for a science program that functions in the lives of high school boys and girls. The community not

only grows on the pupil, but the pupil also feels himself a responsible individual in the community."

Is science being taught properly, or is the child being trained for intelligent participation in life's activities, is a double-barreled question that cannot easily be fused. Unfortunately for the child the science teacher far too often tries to answer the first question as being the important issue which indicates a lack of true educational perspective. Of what value can science be if the child fails in life because of incompetence in science—and this does not refer to the few who fail the course—but to the large number who can give lip service and perhaps pass a memory test.

Building Michael Faraday's "Catpower" electric motor, visiting and working with the United States Weather Bureau, seeing and hearing about the skies first hand in the Case School Observatory on visiting nights, and working with local "Planning Authorities" on a survey of the community are a few of the activities that help make the community a part of the pupil. The Cleveland Academy of Medicine gladly cooperates with Cleveland Schools in booking health experts for talks and discussions with large groups of pupils on such topics as self-medication, proper use and treatment of eyes, ears, nose and mental hygiene. West Technical High School pupils subscribe to this feature with real enthuiasm, recognizing that these are real values as safeguards to insure good health.

The science laboratory therefore becomes a community laboratory and goes beyond the small room in the science compartment. Soil and chemical gardening, photography and other activities can be carried on both at home and in school. Science instruction centered on laboratory projects or science in which community and school laboratory projects forms the backbone, instead of an abstract outline from some book, tend to start the pupils on a science excursion that is not likely to end when the school subject is completed.

PERSONAL AND SOCIAL PROBLEMS OF YOUTH

Attention is being directed increasingly to the determination of the real problems and issues of boys and girls of high-school age. A recent investigation, entitled *An Inventory Study of the Personal and General Social Problems of 256 Students in Grades Seven to Twelve, Inclusive*, has been completed by a committee of the staff of the Ohio State University School.

A check list of 392 problems, gathered by preliminary studies, was submitted to a total of 256 pupils, ranging in number from 36 to 61 in grades seven to twelve. The list was divided into two major sections: "Personal Problems" and "General Problems." Each of the two sections was divided further into categories. Some of the categories were: "Family," "Vocation," "Pupil-Teacher Relations," "Our School," "Self-Discipline, Mental Hygiene and Health," "Planning Work," "Religion," "Sex," "College," and "Social, Economic, and Political Organization."

The pupils' checks of problems in the list which seemed important to them provided the data which is summarized in the report. Comparisons of interest in the problems are made for grades, sex, and categories. The results are most revealing. Sex differences are slight. Personal problems of youth cover a very wide range suggesting great variations in courses based upon pupils' needs. The upper grades show a marked increase in interest in world affairs. Pupils in grades seven to ten indicate greater interest in personal or immediate needs. The results are in part a reflection of the educational philosophy of the particular school.

Science teachers will peruse with interest the votes of the pupils on those problems which may be considered as a part of, or closely related to, science education. They will also find in the report a technique which may be used to determine pupils' needs in the field of science.

YOUTH AND EDUCATION

Much is being written these days about American Youth and their education. Theoretical, philosophical, and practical words come from various directions, and many individuals and committees offer their best ideas on one of the greatest problems confronting the profession today. A check list of 14 publications and 10 forthcoming publications by the American

Youth Commission, 744 Jackson Place, Washington, D. C., may be had on request.

The Research Division of the N.E.A. adds its contribution to the literature on youth in the form of Bulletin No. 5, Volume 18, entitled "What People Think about Youth and Education." The report is an outgrowth of the original plans of the Committee on Implementation of Studies in Secondary Education of the American Council on Education. This Committee turned over to the American Youth Commission the project for a public poll which was subsidized by the General Education Board.

The special committee appointed by the Commission prepared proposed questions for the poll, tested them by a preliminary ballot, and made tabulations of the replies. The *Research Bulletin*, prepared under the direction of Frank W. Hubbard, summarizes in some detail the replies to thirteen questions submitted to over 3,800 adults, in all sections of the country, of different age, race, income, sex, and educational groups.

Representative questions included in the inquiry are: Is education overemphasized? Has education improved? Should youth discuss issues? Do teachers favor the wealthy? Should poor families be helped to educate their children? Is too much spent for schools? Should government provide work for youth?

The summary of replies is challenging to all educators. The general conclusions by the Bulletin Staff are as follows:

1. The American public has a generally favorable point of view toward the present day program of public education.
2. The public believes that the public school should offer fair and equal opportunities to all youth.
3. The public favors a special program for unemployed youth who are not in school.
4. The public is for freedom in teaching and in learning.
5. The public will not be satisfied with a static educational program.

TEACHER EDUCATION

The Commission on Teacher Education of the American Council on Education has just issued a booklet giving a brief statement of the origin and scope of the Commission. This is the first of two projected companion publications which are offered to the public as a report of progress. The Commission began in 1938 a five-year period of study of the problems relating to the professional education of teachers. The booklet outlines the major problems to be studied, describes the cooperative study planned by universities, colleges, teachers colleges and public school systems, and outlines proposed evaluation methods, as well as additional activities now contemplated. Those who are interested in the education and re-education of science teachers and supervisors of science will watch with eagerness the development of the projected work of the Commission.

CONSUMER EDUCATION AID

Aids for the science teacher appear on every hand. A new aid is now offered by Consumers Union of U. S., Inc., 17 Union Square, New York City, and is entitled, "Consumer Class Plan." The release says:

> Each class plan is a complete self-contained unit planned for one hour's teaching. Each plan proceeds from a definite aim: (for example, to develop a basis for the intelligent purchase of toys), offers motivation that will arouse the students' interest, outlines a definite, well-planned procedure to teaching the lesson with maximum pupil participation, suggests summary questions and homework assignments that will clinch the lesson in the students' minds.

The first issue, in mimeographed form, contains eight class plans covering (1) gift-giving, (2) toys, (3) bicycles, (4) ice skates, (5) judging textiles, (6) blankets, (7) luxuries, and (8) consumer quiz. Sample lesson plans may be had upon request.

Abstracts

GENERAL EDUCATION

JERSILD, ARTHUR T. "A Study of Elementary School Classes in Action." *The Advanced School Digest* 5: 129–131; June, 1940.

This article describes a venture in cooperative research, designed to study the impact of everyday classroom situations upon individual pupils, and the interrelationships between pupils and teachers. The technique employed was that of direct observation, supplemented by school records, periodic conferences with the teachers, records of pupil achievement, and such records as could be obtained by informal observation of pupils outside the classroom. Some interesting comments are made concerning this study.

—C.M.P.

TIFFIN, JOSEPH, KNIGHT, FREDERIC B. AND JOSEY, CHARLES CONANT. "Can We Trust Intelligence Tests?" *Science Digest* 7: 15–20; August, 1940.

This article is condenced from the book *The Psychology of Normal People.* The authors answer the question affirmatively. Present tests do, however, have their limitations. There is a real need for better evaluation techniques.

—C.M.P.

MARTIN, VIBELLA (*Chairman*). "Reports and Records at University High School." *University High School Journal* 18: 187–201; June, 1940.

This report discusses the types and records kept by the University High School. A detailed chart indicates the type of records, how obtained, how recorded, general use, use in guidance, transfer, and notations.

—C.M.P.

FRENCH, WILL. "Some Problems Involved in Educating All American Youth." *The Advanced School Digest* 5: 97–100; April-May, 1940.

The author asks twenty pertinent questions and gives brief, pertinent answers to these questions.

—C.M.P.

DURBIN, E. F. M. AND BOWLBY. "Why Men Fight." *Science Digest* 7: 17–24; May, 1940.

This article is condensed from a section of *Personal Aggressiveness and War.* Men fight for possessiveness, frustration, aggression, animism, and persecution.

—C.M.P.

SYMPOSIUM. "Railroads." *Building America* 5: 162–192; No. 6, 1940.

This illustrated pamphlet presents some interesting information on railroad transportation.

—C.M.P.

SYMPOSIUM. "Finding Your Job." *Building America* 5: 194–224; No. 7, 1940.

This excellently illustrated article discusses: (1) jobs for workers, (2) building up a personality picture, (3) building up job pictures, (4) where is job training secured, (5) applying for the job, (6) some workers could prevent being fired, (7) many are unemployed through no fault of their own, (8) too inexperienced to work, (9) too old to work, (10) back to school, (11) new ideas for job hunting, (12) the government as employer, (13) jobs depend on industry, (14) jobs of the future, and (15) how can America solve the job problem.

—C.M.P.

SYMPOSIUM. "Adventures in the Reconstruction of Education." *Educational Research Bulletin* 19: 335–362; September, 1940.

This is the first of a series of articles to appear under the above title. Topics discussed in this bulletin are: the development of experimental attitudes, the nature of experimentation, experimentation in broad experiences, and special opportunities for experimentation.

—C.M.P.

SYMPOSIUM. "Can America Stay Neutral?" *Building America* 5: 130–160; No. 5, 1940.

In the war-torn world of 1940, this issue is most timely. The "World War Balance Sheet" showing what we might have obtained for the fifty billion dollars spent should make one hesitate and think.

—C.M.P.

SCIENCE EDUCATION

TAYLOR, LLOYD W. "Science in the General Education at the College Level." *Science* 91: 560–565; June 14, 1940.

Of more than 1,000 college teachers of science who expressed an opinion, a majority felt that general courses in science were being aimed primarily at the minority who were later to specialize, and were disregarding the best interests of the non-specialist majority. More than 80 per cent felt that the one most important

contribution of science to the non-specialist majority was to develop the ability to think critically. Seventy-four per cent attributed great importance to making students familiar with the facts, principles and concepts of the science in question.

Science courses as reformulated for this group of students should be on an intellectual plane equal to that upon which the conventional courses are pitched. The author advocates a historical approach to survey courses, but agrees that there may be other equally feasible approaches.

—C.M.P.

BRADLEY, JOHN. "Physical or Chemical: A Socratic Dialogue." *School Science Review* 21: 1072–1077; June, 1940.

The difficulties, seeming absurdities, and contradictions in explaining such phenomena as physical changes, chemical changes and energy changes, are well brought out in this socratic dialogue. Chemistry teachers will especially appreciate this article.

—C.M.P.

WRIGHT, R. H. "The Nature and Organization of Scientific Knowledge." *Journal of Chemical Education* 17: 270–273; June, 1940.

This is an excellent analysis of the nature of scientific knowledge. It emphasizes the nature of scientific data and the attitude of science toward its data. Generalizations are founded in data derived from data. A theory combines the three elements: generalizations, hypotheses, and logic.

—C.M.P.

FREUD, HENRIETTA AND CHERONIS, NICHOLAS D. "Retention in the Physical Science Survey Course." *Journal of Chemical Education* 17: 289–293; June, 1940.

This experiment consisted in the repetition, after one year, of the comprehensive examination in physical science given in June, 1937. A group of 112 students was available for the test. The ratio of the mean score of 1938 to that of 1937 was 75.6 per cent. This is a somewhat higher retention score than might be expected by even the more enthusiastic advocates of the survey course. The subject matter which is best retained consists of principles, theories, their applications, and related facts.

—C.M.P.

ASHFORD, THEODORE A. AND SHANNER, WILLIAM M. "Are We Teaching Our Students to Distinguish Between Fact and Theory?" *Journal of Chemical Education* 17: 306–309; July, 1940.

This article reports an investigation at the University of Chicago to evaluate scientific method on three distinct academic levels: No special instruction on the scientific method was given on any of the three levels. The three levels were: (1) the high school physical science general course, (2) the college physical science general course, and (3) the college chemistry sequence. The test item was a principle in chemistry. Conclusions: Students have little difficulty in distinguishing between true and false statements. They have some difficulty in deciding whether a given statement supports or has little of no bearing upon a given principle. In distinguishing between experimental and theoretical statements they have little difficulty if the statement is obvious, but experience difficulty if the statement is not obvious. Increased training in chemistry does not help in this distinction. In all other respects, students do better, the longer their training in chemistry, and the higher their scholastic standing.

—C.M.P.

ABBOT, R. B., AND REMMERS, H. H. "An Experiment with Written Recitations." *American Journal of Physics* 8: 244–245; August, 1940.

"The primary purpose of this experiment was to try written recitations instead of oral ones during the three weekly recitation periods of general physics to see if students could rely mostly upon themselves to master physics lessons by regularly reading and studying the assigned topics in the textbooks rather than listening to oral recitations and chalk talks by the instructors for a week or so, and then cramming, as students say they do, during the night before the test in order to get a passing grade." Results were highly satisfactory as indicated by scores made on the Cooperative Physics Tests for College Students. The students were almost unanimous in asserting the written recitations were a good thing from their standpoint. This seems to indicate that students want to have something in the way of pressure from the outside in order to make them prepare lessons on time.

—C.M.P.

SYMPOSIUM. "Measuring the Results of Instruction in College Physics." *American Journal of Physics* 8: 173–181; June, 1940.

This is a summary report on the National College Physics Testing Program 1933–1939. Also included is data from a teacher questionary. The testing program has not only justified its existence but has also made significant contributions to the development of physics teaching as an art and as a science.

—C.M.P.

ROBERTSON, G. ROSS. "Jobs for Graduates in Chemistry." *Journal of Chemical Education* 17: 259–262; June, 1940.

This is an excellent summary of the shortcomings of college graduates in chemistry—not knowledge or ordinary skills, but the inability to write good English, and lack of alertness. Many helpful suggestions are given.

—C.M.P.

SHOEMAKER, LOIS MEIER AND SHOEMAKER, MORRIS B. "The Mammals of New Jersey." *Department of Public Instruction*, Trenton, New Jersey.

This manual for teachers was prepared for the ninth annual Conservation Week in the schools of New Jersey. Aspects considered: (1) characters and adaptations, (2) homes and food, (3) mammals in winter, (4) mammals as fur bearers, (5) mammals as nuisances to man, (6) live mammals may be studied in the classroom, (7) protection of game mammals, and (8) the conservation of mammals.

—C.M.P.

DUNBAR, RALPH E. "Changing Conceptions of Major Topics in College Chemistry Textbooks." *Journal of Chemical Education* 17: 370–373; August, 1940.

The author analyzed 25 chemistry textbooks dating from 1913 to 1937. Some conclusions: (1) there has been a gradual increase in the size of textbooks, (2) there has been a marked increase in the emphasis on colloids, ionization, radioactivity, and atomic and molecular structure, and (3) greatest emphasis is placed upon the laws and theories of inorganic chemistry.

—C.M.P.

HILDEBRAND, J. H. "Chemistry in Higher Education." *Journal of Chemical Education* 17: 414–417; September, 1940.

The author, a well-known chemist of the University of California, makes out a strong case for chemistry as a part of liberal education. Chemistry offers a wholesome antidote to shoddy thinking, through the opportunities for practice in scientific methods. Another advantage is that it is hard. Chemistry is a real discipline; it has to be understood.

—C.M.P.

SCIENCE

MANN, WILLIAM M. "Man's Closest Counterparts." *The National Geographic Magazine* 78: 213–236; August, 1940.

Gorillas are the heavyweights of monkeydom. This article describes the four great apes: the gorilla, chimpanzee, orangutan, and gibbon. There are 10 illustrations and 10 portraits in color by Elie Cheverlange. —C.M.P.

BRAY, ARTHUR. "How Old Is the Earth?" *Discovery* 2: 155–158; March, 1940.

Various methods have been used for estimating the age of the earth. Radioactive changes indicate that the earth is at least 1900 million years old. An analysis of some meteorites has given an age of 2800 million years. (Note: with this issue, *Discovery*, English magazine attempting the popularization of science, announces that it is a war casualty and ceases publication.)

—C.M.P.

BRAGG, SIR WILLIAM, "Address of the President of the Royal Society." *Science* 92: 93–98; August, 1940.

The writer, in his presidential address at the anniversary meeting on November 30, 1939 alludes to the effects of the war on the Royal Society and to science in general. Four fundamental truths are: (1) Science, the knowledge of nature, is of fundamental importance to the successful prosecution of any enterprise, (2) science is of general application, (3) fruitful inventions are always due to a combination of knowledge and of experience on the spot, and (4) there are difficulties peculiar to the application of science to war purposes. —C.M.P.

ABBOTT, ROY L. "I Knew a Fox." *Natural History* 45: 168–171; March, 1940.

This is a delightful story of Rusty, a two-toed red fox. —C.M.P.

GERTSCH, WILLIS J. "The Houdini of the Spider World." *Natural History* 45: 154–156; March, 1940.

This is the story of the trap-door spider that does a startling disappearing act. —C.M.P.

THONE, FRANK. "Quakes Betray Big Guns." *Science News Letter* 37: 218–220; April 6, 1940.

Seismographs are now being used to locate the positions of big guns just as seismographs have long been used to locate earthquake centers. —C.M.P.

COLBERT, EDWIN H. "Mammoths and Men; The Origin of the Elephant; An Ancient Death Trap." *Natural History* 46: 96–105; September, 1940.

The first and third titles are articles whereas the second is a world map with diagrammatical explanations. Mammoths (now extinct) were bitter rivals of men of the Ice Age and threatened to change the whole course of evolution. Mammoths (ancestors of the elephant) probably orignated in India and from there spread over four continents, including North America.

—C.M.P.

ANONYMOUS. "New Apparatus May Double World's Record High Pressure." *Science News Letter* 37: 211; April 6, 1940.

Scientists of the Carnegie Institution have produced a cascade bomb that develops pressures of 3,000,000 pounds per square inch, (200,000 atmospheres) equivalent to pressures found at 100 miles within the earth. It is believed that the apparatus may develop pressures equal to 754 miles within the earth.

—C.M.P.

Book Reviews

Clark, William H. *Ships and Sailors.* Boston: L. C. Page & Company, 1938. 322 p. $3.50.

This is one of the American Cavalcade Series of books dealing with the various cycles of economic growth of the United States. In it Mr. Clark has ably given the story of our merchant marine, reviewing the past glories and accomplishments of our ships and sailors. The beginning of the sea trade in the early 17th century in New England under the inspiration of Governor John Winthrop, extending into the West Indies trade, down to the latter half of the 19th century when American shipping declined, makes reading of an adventurous and romantic character. Drawings, maps, photographs and references to old documents make the book more valuable to the reader. The rise and fall of cities is told along with the story of American shipping. The book gives the spirit of the days which it depicts. To high school and college students and teachers, as a historical reference and as a reference for general science it is well worthwhile.

—L.M.S.

Phillips, A. J. *Gardening without Soil.* New York: Chemical Publishing Company, 1940. 137 p. $2.00.

This is a new book on soilless gardening for the layman and the scientist, written by one who has made a world-wide study of its development and who has had considerable personal experience with this new horticultural science. It is simple in style, yet with complete technical data on many aspects of the problem, including information on the building of suitable equipment, the compounding of nutrient solutions, together with a discussion of plant pathology and physiology as it applies to soilless culture. He calls attention to the fact that hydroponics is not a horticultural El Dorado and states that "soilless culture is not proposed in place of ordinary garden, but to present soil methods in undercover cultivation" or where vegetation is at present unknown. He cites the instance of the extraordinary results obtained on Wake Island, a trans-Pacific air-liner station, where the sandy and rocky soil prohibits vegetation of any kind, where 120 square feet of tanks give a weekly production of 33 pounds of tomatoes, 20 heads of lettuce, 20 pounds of string beans, 15 pounds of vegetable marrow, and 44 pounds of sweet corn. The book is really an experimental handbook treating the essential elements of growth, the tanks themselves and their nutrient solutions, aggregate culture vs. hydroponics, and soilless culture equipment. —Greta Oppe.

Haslett, A. W. *Everyday Science.* New York: Alfred A. Knopf, 1937. 305 p. $2.75.

As science correspondent of the London Morning Post, the author is an able writer on the part the latest discoveries of science play in our daily life. In a discursive and accurate fashion, he discusses in eleven chapters such things as changes in the home involved in the refrigerator, the use of electric motors, apartments of the future and temperature control; heating and lighting in the home; labor-saving devices and leisure; building; science and crime in connection with photography, bloodstains and ultra violet rays, forgery under the microscope; the farmer versus nature, soil, fertilizers, insects and plant diseases; foods and minerals necessary for the body; accessory food factors, such as vitamins and their uses; height, diet and heredity; engines, fuel innovations; speed, the role of stream-lining, air models and wind tunnels, stratosphere flight. References are given to everyday science constantly, in both England and North America, which gives the material a broad point of view and makes it more comprehensive as well as interesting comparatively. Research from many countries, especially the United States and England has been utilized. This is an excellent book for the student who wishes to get a view of the application of science to human life. It is also a book to recommend to the teacher of general science in high school as an amplifier and stimulant to the material which he uses with his pupils. —L.M.S.

Pfeiffer, John. *Science in Your Life.* New York: The Macmillan Company, 1939. 109 p. $0.60.

A series of twenty-two very short essays covering many phases of science and its relation to our ways of living. The reviewer is somewhat annoyed by such anthropomorphic expressions as "This force is Mother Earth's great love for her own—gravity—by which she pulls things back to herself with invisible apron strings," or again "An object . . . shows a stubbornness not unlike that of human beings." There seems in some cases to be an overstriving for popularization and simplifaction which may tend to leave erroneous impressions rather than clarify. An attempt to show the social values and influence of science runs through the whole book, and is given emphasis in the last essay, "The Power to Kill," which closes with the words: "In the course of its development along useful lines science has increased the power to kill; but this power need not be used in the future. Only three centuries separate Galileo and television. And there are still millions of years to go." —O. E. Underhill.

KEY, CHARLES E. *The Story of Twentieth-Century Exploration.* New York: Alfred A. Knopf, 1938. 310 p. $3.50.

This book gives "a general account of what, in the opinion of the author, are the most important or significant expeditions of the century." It is illustrated by photographs and sketch-maps intended not so much for the student of explorations as for the general reader. It presents facts in a clear, understandable way and without any embroidery. The stories of the expedition hold one spellbound. Explorations of the Amazon, through the wastes of Asia and Tibet, on to the North Pole, among the head hunters of New Guinea, the conquest of the South Pole, the various expeditions to Everest,—these are some of the explorations described. High School students, College students and teachers everywhere will find adventure here. The preparations necessary for expeditions to different parts of the world, the human qualities of understanding and courage and endurance involved, as well as the knowledge gained from descriptions of the different places make the book well worth reading.

—L.M.S.

BURBANK, LUTHER. *Partner of Nature.* New York: D. Appleton-Century Co., 1940. 305 p. $3.00.

This work is edited and transcribed from the voluminous writings of Burbank, by Wilbur Hall who worked closely with him. It presents in a remarkably interesting and clear way the fundamentals of plant growth and propagation, struggle for existence, and the influence of heredity in plant life. It should be on the "must" list for required reading by students of high school biology. This does not mean to imply that it should not be read by others. Anyone will find it fascinating. An introductory section gives a pithy sketch of Burbank's life which makes stand in clear relief his genius in bringing informed intelligence to bear on the problems of plant breeding. Although apocryphal stories of Burbank's very early bent towards things botanical are mentioned, more credit for the stimulation of his interests is given to conversations with his father's cousin and close friend of Agassiz, Professor Levi Sumner Burbank, and to the reading of Darwin. Chapter II sets out the fundamentals of plant breeding as background for understanding the rest of the book which treats of Burbank's work and theories. This chapter gives many fascinating examples illustrating how variation, and hence adaptation to changing environment is provided for through closs-pollination. The chapters which follow tell in a dramatic way the changes which have taken place in plant life under the influence of man's conscious and unconscious selection. It is interesting to see how far along toward the understanding of Mendel's Law Burbank had come in practice, long before Mendel's papers had been made public, and to speculate on what Burbank would have contributed to genetic theory if Mendel's work had not become known.

—O. E. Underhill.

CONN, G. K. T. *The Nature of the Atom and The Wave Nature of the Electron.* New York: Chemical Publishing Company, Inc, 1939. 78 p; 115 p. $1.50 each.

For serious students of the atom and the electron, these two small volumes give the latest results of physical research. Unlike the formal monographs on these subjects written by specialists for specialists, these two books assume no preliminary knowledge but begin at the beginning and by comparatively easy stages carry the reader through the spectacular achievements of the laboratory until as complete and accurate picture as possible is given of the nature of the atom and the electron. The atomic theory is developed historically. Quantum numbers, the interpretation of spectra, and nuclear studies are all included and the problem of electron behavior is fully discussed. Despite the simple beginnings with such questions as, "What is an Atom?" "Can we see one?" "What is electricity and how do we depend upon this 'electrical slave'?" these books are not written for the general non-technical reader but for those who desire a certain amount of technical matter to handle the salient features surrounding the contributions of the atom and the electron to scientific thought.

—Greta Oppe.

HORVATH, A. A. *The Soybean Industry.* New York: The Chemical Publishing Company, 1939. 221 p. $4.00.

The editors state in the foreword that this is a concise book covering a growing industry and they seem to have reached their aim. Many readers will feel that more detail would be desirable, particularly for the research and technical worker.

There are twenty chapters in the book covering the processing of the beans, pressing and refining of the oil, uses for the oil, special products from the oil such as phosphatides and industrial uses for the protein. A selected bibliography of seventy names is included. The extraction of the phosphatides and their uses are covered in great detail in three chapters, and represent by far the most detailed portion of the book. Sections covering treatment of the beans and meal before pressing out the oil should prove of interest to research workers in the field.

The inclusion of a chapter giving detailed composition of American-grown soybeans would, in the opinion of the reviewer, add much to the value of the volume.

The book is written in a pleasing manner, printed in large type, and is quite readable. It

will prove of most value to schools, public libraries, and executives where the need is for a short readable text, covering the major steps in the soybean processing industry.

—J. E. Webster.

MILLER, JOHN ANDERSON. *Master Builders of Sixty Centuries.* New York: D. Appleton-Century Company, Inc., 1938. 315 p. $3.00.

As an engineer by education and profession, Mr. Miller is well qualified to write on the great builders of the world. Clearly and entertainingly in a book designed for the layman, the stories of some of the great engineering triumphs of the ages are told, among them the great Pyramid, the Hanging Gardens of Babylon, the great wall of China, Holland reclaimed from the sea, the great cathedrals of the middle ages, the mysterious cities of the Mayas in Yucatan, the Atlantic Cable, the Brooklyn Bridge, and the Panama Canal. The writings of travelers and historians of the time are drawn upon to make more vivid the author's own account. A list of references arranged for use with the separate chapters is given at the end of the book. Drawings by Chichi Lasley accompany the chapters. For supplemental work in general science and history as well as for the traveler, the book gives sound, interesting reading material.

—L.M.S.

SAND, HENRY S. *Electrochemical Theory.* New York: Chemical Publishing Co., 1939. 133 p. $2.00.

Electrochemical Theory is a theoretical and practical treatise for students and analysts. The author hopes to publish shortly a second volume covering the entire field of electrochemical analysis. The book as a whole hopes to popularize electrical methods and to dispel the belief that the apparatus required is necessarily complicated and costly. It is for this reason that the first part of the book is a detailed theoretical discussion arising from a certain mistrust in applying unfamiliar physical concepts to chemical analysis.

—Greta Oppe.

ANONYMOUS. *The Meteorological Glossary.* New York: Chemical Publishing Company, Inc., 1940. 251 p. $3.00.

The first edition of this glossary was issued in 1916 and was reprinted in 1917 and 1918. The second edition was published in 1930. The progress of meteorology since 1940 has necessitated this third and first American edition. It is a most complete work, explaining fully all the terms and concepts peculiar to meteorology. An alphabetical arrangement is followed throughout with many cross-references, the initial word of each article being in bold type. The International Meteorological Committee at its meeting in London in 1921 passed a resolution requesting the inclusion in future editions of the equivalents in various languages of the words defined. There is a large section devoted to the equivalents of English terms in Danish, French, German, Italian, Norwegian, Portuguese, Spanish, and Swedish, also the international definitions of cloud forms are used. Weather maps, tables, equations and constants are included wherever they are required.

—Greta Oppe.

ANONYMOUS. *The Detection and Identification of War Gases. Notes for the Use of Gas Identification Officers.* New York: Chemical Publishing Company, 1940. 53 p. $1.50.

This book, a first American edition, is a complete little volume on war gases, their physical properties, chemical reactions and tests, subjective as well as objective tests, and identifications.

—Greta Oppe.

HEXTER, PAUL LAUIS. *Make Your Pictures Sing.* San Francisco: Camera Craft Publishing Company, 1940. 188 p. $3.00.

This is a book on methods of perfecting photographic technique. It attempts to clear away the confusions and prejudices that stand in the way of the photographer's making the camera do his own will, for the camera can make many different records of the same scene. Too often the photographer becomes enmeshed in technical details and forgets the most important purpose of photography—making pictures that live. Many useful suggestions to make pictures sing are included in this different treatise, valuable to both beginners and advanced students.

—C.M.P.

GRIFFIN, J. D. M., LAYCOCK, S. R., LINE, W. *Mental Hygiene.* New York: American Book Company, 1940. 291 p. $1.75.

With our increasing knowledge of human nature, it is only natural that mental hygiene has become more important in the processes of modern education. Psychiatry, psychology, and education must work together if we are ever to create a favorable environment for wholesome child development. Work in this field has only commenced.

In this manual of 291 pages, three Canadians have collaborated to give to educators a picture of mental health by surveying the products of our schools and presenting problems of mental hygiene in the home and in the school. The nature of growth and how personality develops, good and bad, are presented with norms of healthy personality development. Classroom problems from school records are carefully diagnosed for faulty personality development among superior children as well as limited mental ability among slow-learning children. The mental hygiene approach to children always calls for a consideration of what is happening to a child outside of school; therefore the diagnostic approach must take into account the home and the community, and the school, assuming that all aspects of education—curriculum, rec-

ords, discipline, examinations, and the like—have significance for the healthy development of the child, must take into account its organization and administration and that major influence in a child's life, its teachers. This very fine book on mental hygiene closes with a challenge to the schools of tomorrow, their philosophy, administration, professional training and selection of teachers, a flexible and greatly enriched curriculum with classroom activities directed by the needs of society and the individual as he fits into the social group, character-building agencies where aspirations, potentialities, and leadership are born. —Greta Oppe.

McKAY, HERBERT. *Odd Numbers or Arithmetic Revisited.* New York: The Macmillan Company, 1940. 215 p. $2.50.

Arithmetic is usually regarded as the Cinderella of Mathematics, the drudge whose duty it is to do everything that is dull. This is more the fault of arithmeticians than of the arithmetic. *Odd Numbers* is a novel and interesting book about arithmetic. This popularization will prove delightful, entertaining reading to all secondary mathematics and arithmetic teachers, and to many science teachers and laymen. It is well within the comprehension of the latter groups.

All chapters are interesting, but especially those on proportion, comparisons, weights and measures, the delusive average, and the construction and solution of problems. —C.M.P.

PARTINGTON, J. R., AND STRATTON, KATHLEEN. *Intermediate Calculations.* New York: The Macmillan Company, 1940. 239 p. $1.65.

As the title of this book indicates, it is intended to meet the requirements of pupils in English schools preparing for the Higher School Certificate, Intermediate Science, First Medical and similar examinations between the General School Certificate Examination and the Examination for the Bachelor of Science degree. The entire book is made up of numerical examples which form an important part of laboratory work. American readers and students of comparative education will find the book valuable in determining what is essential in mathematics for science training.

—Greta Oppe.

CLARKE, JAMES. *Picture of Health.* New York: The Macmillan Company, 1940. 123 p. $0.60.

Here is a new book portraying the story of health, of the systems within our bodies working together to keep us alive. The reader will enjoy not only the story portraying the "essence of living things," but also the delightful animated pictures of Guy Rowe which illustrate the workings of our inner organs to keep us well. The titles of the chapters indicate the manner in which Mr. Clarke has treated the subject of human health. Here are some of them: Millions of Motors, Your Energy, Inside Information, Good Eating, Food Refinery, Enemies You Swallow, Delivery Service, Pumps and Pipe Lines, The Living Filter, Skin and Bones, Outside Information, Growing Up and Growing Old, The Health You Inherit. Since most of the things we do are part of an effort to maintain good health, this small volume should hold an important place in the layman's library. "Reading the book," the author concludes in the final chapter, *"You Don't Know the Half of It,* is like looking down from an airplane: You get a spread-out view or picture of health, an idea of how the body itself works to maintain its efficiency and how you may help it by sensible living," and, since the book does give this "spread-out picture of health," Mr. Clarke suggests a number of fine books to be read for a closer view of the details discussed more or less generally in a book of this size. In today's hurrying world, we have need for such books as *Picture of Health* to help us to grasp important facts and ideas that we haven't time to master completely. —Greta Oppe.

GAMOW, G. *Mr. Tompkins in Wonder Land or Stories of c, G, and h.* New York: Macmillan Company, 1940. 91 p. $2.00.

This is a very interesting application of the Alice in Wonderland technique in explaining the intricacies of modern physics. Mr. Tompkins is a typical bank clerk who wanders into a series of lectures by a famous university professor. Although not understanding much of what he hears he is led to dream at night and the first portion of this book is a description of six such dreams. In the first dream, he finds himself in a universe in which the gravitational constant is a million times larger than in our own universe and the radius of the universe is about 100 miles. Under these conditions matters of gravity and relativity are discussed. In the second dream, he finds himself in a universe in which the quantum constant h, is equal to one erg per second. As a result of this billiard balls exhibit very peculiar behavior. In the third dream, he finds himself in a universe in which the velocity of light is reduced to about 10 miles per hour thus making contraction phenomena visible, and the inhabitants aware of other details of relativity. The remaining dreams carry these ideas further in a very interesting way. The last section of the book consists of the three lectures which Mr. Tompkins is supposed to have heard. These present in straightforward fashion the fundamentals of the relativity of space and time, gravitation and the quantum theory. The author of this book has studied at the University of Leningrad, developed the quantum theory of radioactivity while studying at the University of Göttingen, and has worked on nuclear physics with Professor Bohr and Lord Rutherford. For the past few years he has been professor of theoretical physics at George Washington University. —O. E. Underhill.

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